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THE FORMULATION AND ANALYSIS
OF AN OPERATING AND SUPPORT COST MODEL
FOR THE ADVANCED RPV SQUADRON

THESIS

GSM/SM/75D-17

Nazaire G. LeBlanc
Capt USAF

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THE FORMULATION AND ANALYSIS
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FOR THE ADVANCED RPV SQUADRON

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

by

Nazaire G. LeBlanc, B.A.

Capt USAF

Graduate Systems Management

December 1980

Approved for public release; distribution unlimited

PREFACE

This thesis was initiated in the summer quarter of 1975 while I was a student at the Air Force Institute of Technology (AFIT), in Dayton, Ohio. Most of the research work and initial writing was done prior to the end of 1975. In order to complete the requirements for this thesis, the material was reviewed and updated where it was appropriate. The cost estimates used to exercise the operating and support (O&S) cost model are obviously outdated but were not changed because it was felt that they still provided a quantitative measure in which to make relative comparisons. Even in 1975, the several sources that provided the estimates cautioned against the accuracy of the numbers because they were averages, rough allocations, and applied to generic systems rather than a specific weapon system. This estimating problem existed in the Department of Defense (DOD) in 1975, as it does now, in trying to identify and standardize the reporting of O&S costs by weapon system. I believe the material in this thesis is still of value and will contribute to the further development and understanding of the critical importance of operating and support costs in the development and acquisition of future weapon systems.

I want to express my sincere appreciation to Lt Col Edward J. Dunne, Jr. my thesis advisor, for his advice and many helpful suggestions on improving my thesis. Also, I wish to thank Dr. Dwight Collins for his help in the initial phases of my thesis research and for reading and making constructive comments on the final draft. I also want to thank Lt Col G. C. Saul Young, Jr. for reading and commenting on my thesis. In addition, my appreciation is given to Major John Twigg and others of the RPV Systems Program for providing me with information and ideas on which this thesis was based. Finally, a special thank you is for my wife, Judy who spent many hours, organizing, typing and retyping this thesis.

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ABSTRACT

A study and analysis of the operating and support (O & S) costs of an Advanced RPV squadron was performed. This study concentrated on the determination of costs for operations and support while the weapon system was still in its conceptual phase of acquisition. It was assumed that early decisions made by the system program manager, with respect to design parameters for a weapon system, can have a major impact on the costs for operating and supporting that weapon system.

A cost model was formulated, to be used by the ARPV program manager, that provided operating and support cost visibility. Its purpose was as a tool to provide insight into what cost elements were the high cost drivers. Also, it was intended to be useful in applying different operating and support concepts in order to arrive at the most cost effective squadron concept. For this purpose, a squadron operations and maintenance concept was developed to demonstrate the utility of the model. Finally, several cost variables were examined to show their impact on total O & S costs as they were varied over a range of values.

CHAPTER I: INTRODUCTION

The thesis presented here represents research and work done in the fall of 1975 by this writer. It was completed and submitted in December 1980 to fulfill the requirements for a Masters Degree in Systems Management. Subsequent to the fall of 1975, the Advanced Remotely Piloted Vehicle (ARPV) concept was not approved for advanced development. In its place, the RPV Systems Program Office redirected its effort toward the development of a low cost expendable harrassment vehicle. The thesis is presented from a 1975 perspective with the firm belief that the work can be of value in future RPV approaches and to the development and analysis of operating and support costs of future DOD weapon systems.

Statement of the Problem

The purpose of this thesis is to study and analyze the operating and support costs (O & S) of an Advanced RPV squadron. This study will concentrate on the examination of O & S costs while the weapon system is still in the conceptual phase of the acquisition process. It is the contention of this writer that early decisions made by the system program manager, with respect to design parameters for the weapon system, can have a major impact on the costs for operating and supporting that weapon system. It is also believed that several cost variables can be identified which are different or significantly changed for Remotely Piloted Vehicles when compared with either aircraft or missile systems. The identified cost variables will then be examined in a composite of existing operating and support cost models.

The Advanced Remotely Piloted Vehicle (ARPV) program has been established to "assess the feasibility of a total system approach for a multi-mission capable RPV, to evaluate cost effectiveness, to perform preliminary tradeoff and design analyses for improved system definition, and to provide a basis for a

decision to proceed with follow-on development."[1] The multiple mission capability refers to the strike, electronic warfare, and reconnaisance missions for the early 1980's time frame.

Organization

The thesis is organized into six chapters. In this first chapter, a statement of the problem is given to show the goal and direction that will be pursued. This will be followed by an historical look at RPV's up to the present time in order to give some insight into the uniqueness of the weapon system. Next, a discussion about Life Cycle costing will lay the background for studying operating and support costs and the significance of those costs. Chapter two will present the methodology used to approach the subject of this thesis. This will include the scope and limitations of the research, the assumptions made, the guideline recommended by the ARPV Program Office. In Chapter III, the results of a literature search of operating and support cost modeling will be reported that will include data related problems, weapon system design characteristics and an analysis of current operating and support modeling technology. Chapter IV will be devoted exclusively to the development of an ARPV Squadron Concept, a necessary basis for developing the operating and support cost elements. In Chapter V, the operating and support cost model for the ARPV will be developed and analyzed. Cost variables that are unique or significantly changed from other weapon systems will be identified and analyzed for their sensitivity to overall operating and support costs. Chapter VI will summarize the thesis findings, state the conclusions made as a result of these findings, and make recommendations on the use of this thesis

[1] Program Management Plan for Advanced RPV Program System Studies, (PMP 75-002; Wright-Patterson AFB, Ohio: Aeronautical Systems Division, 11 A.

and for further research in the area of operating and support costs.

Background to Remotely Piloted Vehicles

A logical place to begin in discussing RPV's is to answer the question, why is there interest in RPV's? The answer involves four issues that confront the Department of Defense on any weapon system development: the decreasing availability of dollar resources, the increasing cost of men and machines, a continually increasing enemy threat, and the newly emerging sensitivities, national and international, to the value and presence of man.[2] With these issues in mind, the Air Force has begun to develop a low-cost, recoverable, multimission RPV weapon system to supplement expensive manned aircraft systems. The RPV's would be used in place of manned aircraft in high-risk environments to reduce missions costs and the possible loss of men. Further justification for the RPV development involves the shift of the balance of military power in Europe. The Warsaw Pact nations outnumber the North Atlantic Treaty Organization (NATO) forces in troop strength, numbers of battle tanks and in quantities of aircraft. Add to this the advanced mobile radars and thousands of anti-aircraft guns and surface-to-air missiles and it becomes clear that military power in Europe is numerically weighted in favor of the Warsaw Pact nations. To offset this unfavorable shift in military balance one option that the Air Force is studying is to deploy RPV's in large numbers in order to overwhelm the defensive systems.[3] "The RPV is built with attrition in mind and would be employed against highly defended targets. It

[2] United States Air Force Drone/RPV Mission Analysis, (Volume I, ASD/XR 74-2, Final Report, February 1974).

[3] Lt. Col. E. J. Kellerstrass, "Drone Remotely Piloted Vehicles and Aerospace Power", Air University Review (Sept-Oct, 1973), p. 46.

is fearless, avoids the extreme exposure of expensive manned systems, and reduces the number of potential hostages."[4] The above ideas give some strong reasons for developing RPV's. In the following paragraphs, some background in the development of the RPV concept is presented in order to show how some of the Advanced RPV concepts were developed.

The first serious effort in modern times to develop a remotely piloted vehicle was by the U. S. Army in 1918 at Dayton, Ohio. This military version of an RPV was known as the Kettering Bug. It was designed to carry a 200 pound warhead of high explosives at a speed of 130 m.p.h. for a distance of 75 miles and cost no more than that of firing an eight inch artillery shell. The Bug was successfully test flown, but World War I ended before the vehicle could be approved for production. The idea then lay dormant until World War II, when attention again turned to the development of ordnance delivered by remote control.[5] The most spectacular was the German V-1 Buzz Bomb that was launched against England, causing substantial damage and over 14,000 casualties. The most significant development of RPV's during World War II was the use of these vehicles as aerial targets for training antiaircraft artillery crews and for air-to-air gunnery practice. One such vehicle was the Northrop OQ-2A. It was a radio-controlled, 100 lb., low speed, high wing monoplane vehicle that could climb, dive, and turn within line of sight distances of its control station.[6] This development led to the first target drone vehicle production line.

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[4] Ibid.

[5] United States Air Force Drone/RPV Mission Analysis, (Volume I, ASD/XR 74-2, Final Report, February 1974).

[6] Ibid.

A new entry into the target drone field, in the late 1940's, was the Ryan Aeronautical Company. This company was to become the prime contributor of target drones in the coming decades. This contribution began when Ryan Aeronautical was given the first competitively awarded contract for a subsonic, jet-propelled, unmanned aircraft. This vehicle was designated the XQ-2 with the primary function of testing and evaluating ground-to-air and air-to-air missiles. The Q-2A, the production model, quickly proved its usefullness as a target drone for the training of aircrews. When it became necessary to add radar augmentation and scoring devices for realistic target threat simulation, degradation of aerodynamic performance resulted from the addition of wing pods. The outcome of this difficiency was a proposal by Teledyne-Ryan for a new design which had adequate internal space for augmentation and scoring devices and with a larger engine. This drone became known as the BQM-34A Firebee.[7] It was a high subsonic vehicle, near Mach 0.9, capable of operating at altitudes from 200 to 50,000 feet at ranges up to 600 miles by remote radio control. Approximately 4,000 Firebees have been produced so far. This availability of the Firebee enabled the drone to be used for a variety of other missions such as photography, information collection, leaflet dispensing, and electronic warfare support.[8]

The current inventory of RPV systems is composed of vehicles that are directly related to the procedure in which programs were developed. The usual process was to select and modify an existing target drone to meet an urgent operational reconnaissance need instead of spending time

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[7]Kellerstrass, op.cit., p. 48.

[8]United States Air Force Drone/RPV Mission Analysis, (Volume I, ASD/XR 74-2, Final Report, February 1974).

to design and develop an optimum RPV. The number and diversity of these modifications, derived from an established vehicle design, have been very extensive. An example of the process was the development of the AQM-34L for low-level reconnaissance in Southeast Asia. Additional adaptations were developed for the RPV primarily in the reconnaissance role. There was, however, a mission application developed for tactical electronic warfare support. The activation of the 11th Tactical Drone Squadron on 1 July 1971, at Davis-Monthan AFB, Arizona, marks the official beginning of employment of unmanned vehicles in tactical operations.[9]

In recent years an effort has been made to develop RPV's with cost effectiveness as a primary goal. New RPV designs such as the Compass Cope Program for the development of a high-altitude, long-endurance RPV have received much attention. Significant in this program is that the vehicle will be capable of taking off and landing under the control of a remotely located controller. The ability to take off from the ground and then land is a significant cost saving procedure that is being developed. Prior RPV's required airborne launch from a DC-130 and a recovery by the Mid-Air Retrieval System (MARS), which is a helicopter recovery technique. These methods were very costly and necessitated more cost-saving methods. Another mission application is the tactical air-to-ground strike mission, where hardened or heavily defended targets will be attacked by recoverable RPV's. "The relatively low-cost of the RPV makes it an ideal delivery system for this type of mission. Although the primary interest at this time is the use of RPV's against heavily defended, high-value targets, such as a SAM site, there is little doubt that close air support

[9]Kellerstrass, op.cit., p. 49.

and classical interdiction missions could be considered in the future."[10]

The next logical step in the development of RPV's is to design a multimission, low-cost vehicle that will incorporate most of the cost saving concepts that have been proposed. This task is essentially what the Advanced Remotely Piloted Vehicle (ARPV) program is attempting to do. The needed technology is available now. What is needed, is a new approach to designing low-cost vehicles that does not require the military specifications and qualification testing standards of manned-aircraft systems. "Creativity and ingenuity in applying the technology to design concepts will be required in order that greater strides in this area can be accomplished and costs held to a reasonable factor."[11] The ability of RPV contractors to develop this approach is the key to the future of RPV's. If this is not done, we will never see them in the quantities necessary to be effective.[12]

Life Cycle Costing Application

The Air Force uses the concept of life cycle cost (LCC) in the development, acquisition, and modification of defense systems and subsystems. The extent to which LCC will be used is determined by the acquisition strategy and related decision processes. The type of decisions in which LCC is expected to be used include: design choices; selection of a source; evaluation of engineering change proposals; and determinations on whether or not to proceed to subsequent acquisition phases.[13] The

[10] Ibid., p. 52.

[11] Ibid., p. 54.

[12] Brig. Gen L.P. Hodnette, Jr., "Remotely Piloted Vehicles", National Defense, (Mar-Apr, 1974), p. 424.

[13] AFR 800-11. Life Cycle Costing (LCC). (Washington D.C.: Department of the Air Force, 3 August 1973), p. 1.

concept of life cycle costing used here is not the same as the term life cycle cost. This latter term refers to the total cost to the Government of acquisition and ownership of that system over its full life. It includes the cost of development, acquisition, operation, support and where applicable, disposal. The term, life cycle costing, usually refers to a procurement technique in which decision making is enhanced by considering all elements of life cycle cost. AF Regulation 800-11 says that "the main objective of life cycle costing is to consider ownership (operation, maintenance, support, etc.) cost, in order to provide visibility to economic advantages of the various design/development options and acquisition decisions."[14] In figure 1, the cost spectrum of the weapon system life cycle is shown. The acquisition phase includes the costs for concept formulation, advanced development (validation), full scale development, and production. Prior to advancing into each of the above phases a DSARC must be convened and a decision made to go ahead in the program. During the production phase, the operational phase will begin as weapons are deployed in sufficient numbers to allow the Air Force units to attain operational capability. This operational phase will continue to generate operating and support costs until the weapon system or equipment is phased out. The summation of the costs for the acquisition and operational phases provides the life cycle cost of the weapon system.

The use of Life Cycle Costing in decision making is not intended to make minimum cost as the only or predominant decision factor. A consideration for system effectiveness is also included in any decision making concerning a system or subsystem procurement. By system effectiveness we refer

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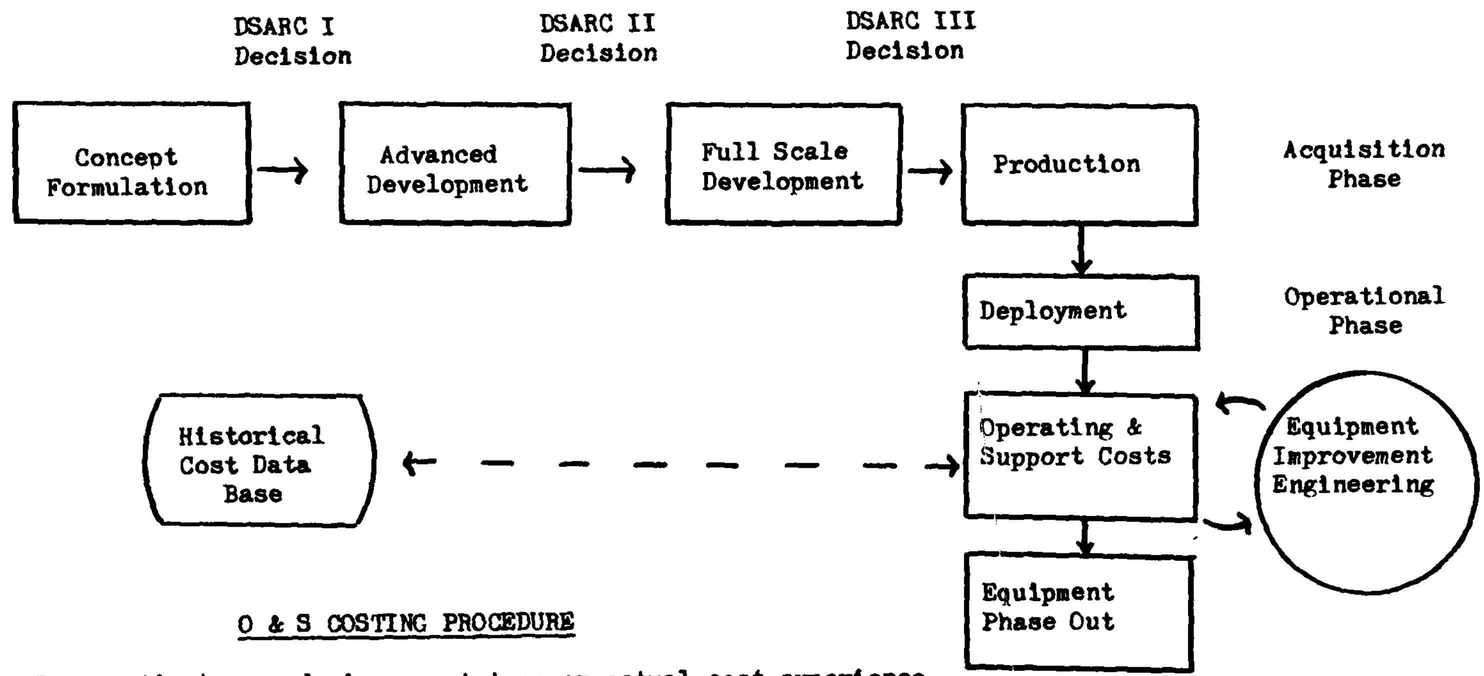
[14] Ibid., p.2.



O & S COSTING PROCEDURE

Base estimates on design, prototype or actual cost experience.
Refine estimates throughout DSARC review.
Keep track of how/why cost estimates change.
Produce best O & S cost estimate at each decision point.
Compare estimates against current and comparable system costs.
Focus DSARC management attention on O & S costs.

Figure 1

WEAPON SYSTEM LIFE CYCLE/COST SPECTRUM[15]

[15] Life Cycle Costing Guide For System Acquisitions, Department of Defense, (January, 1973), p. 2-4.

to the analysis of a system potential and/or capacity to perform its assigned mission.[16] It is the intention, though, that life cycle costing will be used to insure a proper balance between cost and effectiveness of the system. For example, emphasis on an initial cost may result in a lower acquisition cost but cause ownership costs to be unreasonably high. By considering a higher initial cost with resultant higher reliability and maintainability, lower life cycle cost may actually be achieved.

Thus, a cost-effectiveness analysis is imperative for sound decision-making at all levels. It is most essential for those decisions made by the Defense Systems Acquisition Review Council (DSARC) when considering the continuing viability of a system effort. This includes decisions concerning whether to initiate a program and subsequently whether to discontinue it, or to remain in the existing Acquisition Phase, or to proceed to the following phase. The realization that a cost-effectiveness analysis will be made should provide the motivation for contractors to use LCC analysis in their initial design concepts and throughout the Acquisition Phases, even before LCC estimates are required as contractual commitments.[17]

Significance of Operating and Support Costs (O & S)

In the past, the Department of Defense (DOD) has concerned itself primarily with the research, development, and production costs incurred from the decision to develop and buy a new weapon system or subsystem.

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[16] Life Cycle Costing Guide For System Acquisitions, Department of Defense, (January, 1973), p. 2-3.

[17] Ibid., p. 2-2.

But, now, the constantly decreasing amount of defense dollars has forced DOD to consider more than just the initial cost to procure that system. Increasing interest is being concentrated on those costs incurred after a weapon system is deployed and operational. These costs are the costs to operate and maintain that weapon system for the entire period of its useful life. Analysis of current and past systems indicates that well over 50 percent of total life cycle cost for a particular weapon system is spent on operating and support costs. When looking at the costs incurred for one year, specifically FY 74, approximately $25 billion or 30 percent of the Defense budget was spent just to maintain existing equipment.[18] Just the large amount of dollar resources consumed necessitates a more comprehensive look at weapon system costs. Methods for reducing these costs must be given serious thought. The importance of these reducing methods must be brought to the attention of the DOD in all decisions made that affect the development and buying of new weapon systems. Thus, it is imperative that the cost impact of potential system (O & S) costs be understood and reviewed during the acquisition process on an equal priority with projected unit production costs.

Objectives of Research

The objective of this thesis is to present an Operating and Support cost model for the Advanced Remotely Piloted Vehicle that can be used to investigate cost variables that have a significant impact on total O & S costs for the ARPV squadron.

Specific objectives of this thesis are:

1. To study operating and support costs of weapon systems.

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[18] Operating and Support Cost Estimates, (Department of Defense, May, 1974), p. 2.

2. To analyze cost elements of existing operating and support cost models.

3. To develop an Advanced RPV Squadron concept to include the command structure, basing, personnel and training requirements, maintenance concept, operations concept, ARPV description, and mission profiles.

4. To formulate an ARPV Squadron operating and support cost model.

5. To identify and analyze cost variables that are uniquely found and/or significantly changed in an ARPV squadron.

The next chapter will present the methodology used to accomplish the objectives of this research. This will include the scope and limitations of the research, the assumptions made, and the approach taken.

CHAPTER II: METHODOLOGY

Scope and Limitations of Research

The research was conducted on current operating and support cost technology. Specific goals were to analyze examples of models currently being used, the data sources used and problems related to them, and the impact that reliability and maintainability have on the operating and support costs of a weapon system. This background of information was needed for the formulation of an Advanced RPV (ARPV) cost model. This cost model was the primary objective of the research undertaken in this thesis for the Advanced RPV program manager.

The limitation of time placed the constraint of one quarter (10 weeks) to perform the research and to write this thesis. Thus, it was necessary to concentrate only on those subjects that this writer considered most important to the development of an O & S cost model for the Advanced RPV.

The primary sources of data used included discussions with ARPV program manager, propulsion data from contractors, and cost standards from several Air Force publications. Several operational and maintenance concepts from present RPV squadrons, missile units, and RPV development programs, i.e. Compass Cope, influenced the design of the resultant O & S Cost Model. Much of the data examined concerning present RPV units was determined to be irrelevant or inaccurate by this writer, in consultation with the ARPV program manager and other ARPV system engineers.

Assumptions

The Advanced RPV program is currently in the early conceptual phase of its life cycle. Due to this, many basic assumptions are made concerning

the concept of an Advanced RPV Squadron. These assumptions form the basis on which the operating and support cost model is developed. Where it is possible these assumptions are based on current weapon systems, related RPV development programs, or engineering design estimates from several contractors. Chapter IV will present the concept of an operational ARPV Squadron. This concept was discussed with the ARPV program manager for its feasibility and was found to be a valid assumption on which to base the development of the cost model.

There are specific guidelines, presented in the ARPV Program Management plan for the Conceptual Phase, that provide direction for the development of a squadron concept. These guidelines are that the ARPV would:

1. Be low in cost to acquire, operate, and support when compared to other Air Force systems or options for similar missions.
2. Employ minimal numbers of personnel to maintain and operate and also require low skill levels.
3. Be capable of operating in significant numbers for those missions that require numbers to be effective.
4. Employ a launch and recovery approach which is significantly improved over the current practice. Launch and recovery must be relatively simple and require minimal off-vehicle equipment.
5. Be derived from designs which do not apply full military standards and specifications where cost or other considerations result in benefit to the government.
6. Consider design for vehicle survivability as a major factor to be traded in the cost effectiveness analysis.[19]

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[19] Program Management Plan for Advanced RPV Program System Studies, (PMP 75-002; Wright-Patterson AFB, Ohio: Aeronautical Systems Division, (11 April 1975).

Approach

The approach taken to accomplish the research objectives of this thesis is to first, conduct a literature search into current Operating and Support (O & S) cost technology. This includes a look at the status of O & S cost technology within the Department of Defense, the problems related to collecting O & S cost data by weapon system, and the current thinking in O & S cost model technology. The primary sources for this research are the documents in the Life Cycle Cost Reference Library, maintained by the Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, located at Wright-Patterson Air Force Base, Ohio. Next, this writer examines three currently used cost models for their applicability to the development of an Advanced RPV (ARPV) O & S cost model. These models are the Missile Annual Cost Estimating (MACE) model from Air Force Regulation 173-10, the Cost Analysis Improvement Group (CAIG) model from the Operating and Support Cost Development Guide for Aircraft, and the Logistics Support Cost (LSC) model. These models are examined for cost elements that best represent the cost elements expected to be found in an ARPV squadron.

This thesis will develop an ARPV squadron concept, in chapter IV, in order to identify the elements that generate costs and combine to form total O & S costs. The sources for this squadron concept are the ARPV program manager, RPV System Program Office (SPO) personnel, Contractor proposals for the conceptual phase, current missile operation concepts of the Strategic Air Command, and from assumptions made by this writer based on four years experience on a Titan II missile crew. Next, the O & S cost model will be developed from a composite of the MACE, CAIG, and LSC cost models as shown

in figure 2. This composite model will combine those elements that best describe the costs expected to be found in the ARPV squadron.

The last objective of this research will be to analyze the cost elements of the ARPV O & S cost model by investigating the cost variables that make up the individual cost elements. Several of these cost variables will be analyzed to show what their impact is on the total O & S cost for the ARPV squadron. Those cost variables that have the greatest impact on total O & S costs will be identified. This will be done by first giving estimates to each of the variables and then demonstrating the sensitivity of total O & S costs to changes in selected variables. The estimates given for the sensitivity demonstration will be used in this study only to show relative changes in total O & S costs. Sources for the estimates are the USAF Cost and Planning Factors (AF Regulation 173-10), the DSARC Operating and Support Cost Estimates Guide, the Logistic Support Cost Model User's Handbook, and where necessary the best estimate of this writer. There will be additional discussion concerning the cost variables in chapters IV and V.

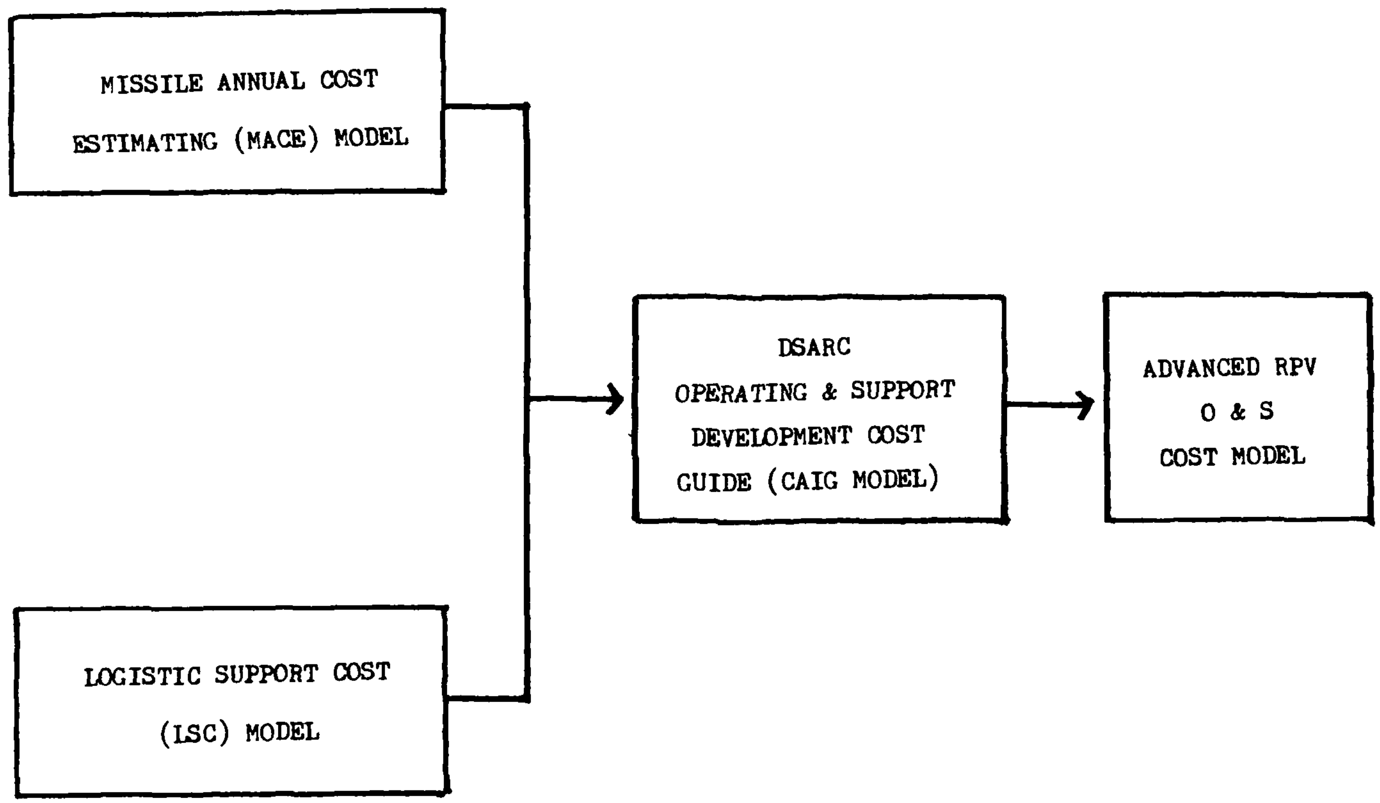

Figure 2. Operating & Support Cost Approach

CHAPTER III: CURRENT OPERATING AND SUPPORT COST TECHNOLOGY

This chapter will present the background of information upon which this research effort was based. The chapter begins with a look at the status of current operating and support (O & S) cost technology within the Department of Defense. Then the problems of the existing data base will be discussed and their influence on operating and support cost estimating. Next, the present status of operating and support cost model technology in the Department of Defense will be examined and described in the form of three currently used cost estimating models. These are the Missile Annual Cost Estimating model from AFR 173-10, the Cost Analysis Improvement Group model from the Operating and Support Cost Development Guide for Aircraft, and the Logistics Support cost (LSC) model. The last section of chapter III will present some fundamental concepts used in developing operating and support costs of a weapon system.

The Status of Operating and Support Cost Estimating

The life cycle cost (LCC) of a weapon system includes the costs for research and development, acquisition, and operating and support. This last item, operating and support, is often referred to in Department of Defense (DOD) documents as ownership costs for the weapon system. These ownership costs have attracted much concern in recent years because of the high cost to maintain current weapon systems and the continuing pressure to reorder national priorities. Current estimates attribute more than half of a weapon system's total life cycle cost to its ownership

costs which are fixed by the weapon's design, mode of employment and personnel requirements.[20]

An additional factor that has attracted both public and Congressional attention has been the phenomenon of "cost growth" in new weapon systems. This is the increase in cost estimates caused by economic and technical escalation of the original cost estimates for those weapon systems. The technical escalation occurs because of the engineering problems that arise during the design of the equipment for the new system. Also, unforeseen requirements that are imposed by the Air Force after contracts are started can cause additional technical escalation. The "cost growth" phenomenon has resulted in specific recommendations from committees such as the Fitzhugh panel on guidelines for attaining economies in the acquisition process.[21] Subsequently, Congress has begun to exert pressure on the DOD to improve its techniques for estimating both the investment and operational costs of new systems. This has been difficult because past DOD cost estimating has concentrated on research and development (R & D) and acquisition costs, not O & S costs. There are two major reasons for this. First, when the Defense budget was submitted, requests for R & D and procurements funds were related directly to major weapon systems. Thus, these costs were made visible to both DOD and Congress. On the other hand, O & S costs were funded by specific appropriations such as Military Personnel, Operations and Maintenance, etc., which could not be easily associated with a particular

[20] Methods for Evaluating the Cost/Effectiveness of Alternative Support Plans for Major Weapon Systems, Logistics Management Institute, Project 6P Report, (September 1965).

[21] G.W. Fitzhugh, et al., Defense for Peace: Report to the President and the Secretary of Defense on the Department of Defense, The Blue Ribbon Defense panel, Washington, D. C., (July 1, 1970).

weapon system. The second reason was that boundaries and costs of R & D and acquisition were much easier to specify than were those of O & S. This can be demonstrated by remembering that the acquisition of a weapon system is fairly well bounded and costed by identifying the production contracts. But, once the weapon system was in the inventory of one of the Military Departments, it became only one element of a military force and, for many costing purposes, inseparable from the other elements that made that force effective.[22]

Recently, the Office of the Secretary of Defense (OSD) expended considerable effort to solve some of the difficult problems of defining and estimating O & S costs. This effort has been made through the Defense Systems Acquisition Review Council (DSARC) and its supporting arm, the Cost Analysis Improvement Group (CAIG) in the form of an expanded role that includes a review of O & S costs of proposed new weapon systems. The past DSARC/CAIG reviews dealt primarily with research and development and procurement issues and their related costs. Very little attention was given to costs for personnel, maintainance, and other resources that continue for the entire operational life of the weapon system. These costs usually exceeded the costs related to the acquisition of the system. When the DOD budget was examined for one year, the total O & S cost for operating and supporting all weapon systems claimed well over half of that budget. If these costs continue to increase as they have in recent years, the availability of resources for force structure modernization will be threatened. Control of these costs can be gained to a large degree only at the points at which go-ahead decisions are made regarding

[22] Weapon System Ownership Cost Modeling, Phase I Task 75-1, p. 5.

weapon system development and procurement by the DSARC.

Operating and support costs are largely, but not exclusively, driven by basic and early decisions about system performance, reliability, and maintainability, and about the environment in which the system is to be operated and supported. These decisions are first considered in the Conceptual Phase after analyzing, estimating, and evaluating different design alternatives and their respective life cycle costs. Due to the recent cost growth problem and reorientation of National Defense priorties, budgets, and management, the Department of Defense has emphasized the importance of O & S cost implications in Directive 4100.35. This document requires that:

> 1. planning the logistic support requirements shall begin at the Conceptual Phase...(and) proceed with continuity through the life cycle of the program.
>
> 2. design of all operational systems...shall take into account the aspects of logistic support...Tradeoffs appropriate to the stage of development shall be made that will maximize the effectiveness and efficiency of the support system...the operational environment and the logistic support requirements which are the result, will be addressed during the tradeoff stage of the system design process. Change to either the system or to logistic support needs will be fully evaluated for the impact on the total system.[23]

Thus, if better and more reliable methods for making system tradeoff evaluations can be formulated and used early in the weapon's design, then maybe all the subsequent development decisions can be concentrated on reducing life cycle costs. This idea suggests that O & S costs cannot be treated separately from research and development and procurement costs. Many procurement costs are a function of the same considerations that shape operating

[23] Development of Integrated Logistics Support for Systems and Equipments, DOD Directive 4100.35, U.S. Government Printing Office, Washington, D. C. (1 October 1970).

and support costs, such as basing, mobility, maintenance concept and others.

Other guidance on operating and support costs come from the 5000 series of DOD directives and instructions. DODD 5000.1 states specifically that "Cost parameters shall be established which consider the cost of acquisition and ownership..." and that "Logistics support shall also be considered as a principal design parameter..." Additional directives and instructions in the 5000 series specify repeatedly the inclusion of ownership costs in cost estimates, the designation and testing of reliability and support requirements, and the consideration of logistics support requirements.

The actions by OSD in stressing O & S costs are having a positive effect on the military departments. Life cycle cost estimates and reliability and maintainability goals are beginning to become visible in the DSARC/DCP (Decision Coordinating Paper) process. Despite this, there is still a need for greater OSD participation in O & S issues. The CAIG efforts have been primarily directed at the O & S costs of aircraft systems as demonstrated in its' Operating and Support Cost Development Guide for Aircraft Systems. This guide contains the essential ingredients for the preparation of an estimate using aggregative cost factors and estimating relationships. However, very little analysis of O & S factors is made. What is needed is for OSD to develop an analytic capability specializing in the evaluation of O & S characteristics of weapon systems in general. Also, the analytic capability must be structured in such a way that it can effectively support the DSARC/DCP process. The need for analytical support is clearly stated in a recent report from the

Logistics Management Institute to the Department of Defense. The report stresses that OSD "provide analytical support which, during the formulation and execution of a system acquisition program, can improve the visibility and accuracy of O & S costs as related to the following:

*The ability of the DOD to afford to operate and support the system.

*The O & S cost impact of alternative systems.

*The design trade-offs which affect O & S costs.

*The program thresholds which would focus DOD management attention on key O & S related issues of the program.

*The feasible support alternatives.[24]

The Existing Data Base

Current O & S cost estimating is being hindered because there are no formal data collection systems in the military departments that give total O & S costs for a particular weapon system. "The data needed for O & S cost models are assembled on an ad hoc basis from a variety of information systems, reports, cost factor handbooks and studies."[25] A few cost categories of direct cost for many weapon systems can be identified with relative ease. The difficulty arises when one attempts to identify indirect costs such as overhead for these same weapon systems.

Table I represents the data sources available to the Air Force for obtaining O & S costs for aircraft systems. Note that the sources indicated under the "Planning Factors" label do give information by weapon system. However, these data sources are developed from gross averages and are published with a warning to those who may use them in

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[24] Weapon System Ownership Cost Modeling, Phase I Task 75-1, p. 9.

[25] Ibid, p. 43.

TABLE I

DATA SOURCES FOR OPERATING & SUPPORT COSTS[26]

	Data Collection Systems								Planning Factors	
	Maintenance Data Collection System (MDC 66-1)	Maintenance Production Cost System (G072)	*Appropriation General Ledger Account Cost Program (H057)	Base General Accounting System (H069)	Maintenance Labor Distribution (G037C)	AFLC Retail Stock Control Distribution (D033)	Flying Hour Reporting System (AFM 65-110)	*Increased Reliability of Operational Systems (IROS)	*AFM 173-10	*AFLCP-173-3
I. MILITARY PERSONNEL										
Direct					X		X		X	
Support					X				X	
Training					X				X	
II. MAINTENANCE										
Depot	X	X		X				X	X	
Non-Depot	X			X	X			X	X	
III. RECURRING EXPENDITURES										
Spares	X		X			X			X	X
Munitions			X						X	
Modifications		X	X						X	
POL				X					X	

***Identifies to Weapon System**

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26 Weapon System Ownership Cost Modeling, Phase I, Task 75-1, p. 35.

non-standard situations. These cost factors may not be acceptable for use in estimating the O & S costs of new systems or for old systems in new environments. Also, Table I identifies only two data collection systems, H057 and IROS, that relate costs directly to a weapon system. The data gathered by the other systems can eventually be categorized by weapon system only after considerable effort is made in the field and after making some rough allocation decisions. This is because current data systems in the Air Force are designed mainly as production control and scheduling tools rather than cost accounting tools. When asked to produce cost data by weapon system, the data cannot be obtained from one source. Dictionaries of equivalent terms, such as Federal Stock Numbers (FSN) to Work Unit Codes (WUC), must be generated before the data can be presented in the desired format.[27]

A recent paper by Fiorello of Rand gives an accurate description of the problems facing the Air Force in obtaining O & S cost data by weapon system from current data systems. They include:

> First, there is no one data system that provides weapon system life cycle costs, or even costs of ownership for any weapon system. It is necessary to piece together the total cost from many data system products.
>
> Second, depending upon the level of support activity for the data source, the cost detail and reporting nomenclature and structure is different. Resource consumption at the depot level is monitored and measured in terms of Federal Stock Class (FSC), Federal Stock Numbers (FSN), Repair Group Category (RGC) and Mission Weapon Designation Series (MDS), and at the base level by Work Unit Code (WUC) and organizational entity. In addition, certain items like avionics equipment are procured with Army-Navy (AN/XXX) nomenclature. Compounding the problem of multiple nomenclatures is the fact that there is no complete,

[27] _Ibid_, p. 34.

official correlation between FSNs and WUCs. The current practice of purchasing items by AN designation, managing them by FSNs and maintaining them in terms of WUCs makes it almost impossible to accurately identify logistics support cost at the item level. In general one has to resort to allocation schemes.

Third, the acquisition data available from the contractors Cost Information Reports (CIRs) and the System Program Office (SPO) Selected Acquisition Reports (SARs) are often too aggregated. For example, it is not possible to identify the spares breakout by engines, avionics, etc., or the number and type of support equipment (e.g., AGE) for the different subsystems.

Fourth, the Air Force Resource Management System, which provides accurate accounting data for resource management and consumption by base level organizational entity, allows only partial weapon system visibility. This is particularly the case at those bases with multiple stationed weapon systems and common support activities.

Fifth, not all the costs needed for life cycle analysis are collected for convenient weapon system assignment or allocation, and not all the costs reported are "actual costs". Examples of omitted costs are system manager and item manager personnel time, computer support time, facilities support personnel, capital amortization, and equipment depreciation. Also, in many data systems work-in-process is not reflected. Some data systems incorporate overhead allowances, but in general they are understatements.[28]

Underlying all these problems is the fact that all the current data collection systems are intended for purposes other than weapon system cost accounting. Thus, the general consensus is that the current Air Force data collection systems are inadequate to give O & S cost data by weapon system.

Present Model Technology

The need for interaction between the weapon system designers and the logisticians occurs early in the Conceptual Phase of the program. Questions that need to be answered are similar to the following: How

[28] M. Fiorello, "Data Issues Related to Life-Cycle Costing During Weapon System Acquisitions", WN-8679-PAE, The Rand Corporation, (May 1974) p. 5-6.

large a force is required? How should it be based and supported? What kind of operations concept should it have? What are the resource requirements? What are the operational parameters of the weapon system, such as speed, range, reliability, and turnaround time, etc.? The answers to these questions determine the inputs to the cost estimating model that will be used to supply the necessary information for making tradeoff decisions. The program manager should have the capability to formulate and apply those models that are best able to highlight areas of high cost or resource impact among all the alternatives available. Properly designed operating and support cost models should "highlight the interaction between reliability and support postures and between the alternative methods of providing operational readiness with mixes of support resources."[29] This type of analysis therefore relies upon a functioning support system together with the corresponding operating environment into which the support system must be phased. In essence, the O & S cost model should be able to do the following tasks:

1. Examine the impacts of operational requirements on design and support alternatives (mobility, and so on).

2. Identify areas of high support cost as a consequence of design decisions, and point out preferred design alternatives (performance/support tradeoffs).

3. Make useful comparisons of alternative support postures.

4. Develop budget estimates (economic analysis) during the advocacy process.

5. Act as evaluation tools in the source selection process--and to define incentive goals and other contract guarantees.[30]

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[29]"Using Logistics Models in System Design and Early Support Planning", Rand Report #R-550-PR,(February 1971), p. 30.

[30]Ibid.

The choice of a cost model that performs the above tasks should be carefully made. The decision maker should review the appropriate cost models with respect to the specific objectives that he is required to accomplish. The approach that is used in this thesis is one that is supported by the Logistics Management Institute. This method aids the decision-maker by separating the more feasible operating and support cost models into two categories:

Type I: These are Charts of Account that identify and aggregate the cost elements necessary to give a measure of an organization's operations or of a weapon system's claim on the resources of that organization.

Type II: These permit the manipulation of parameters for the purpose of testing alternative strategies, creating an optimum strategy or estimating the cost elements of the type I models.[31]

The type I models are those models that can be used when the decision-maker wants to measure the operating and support costs of a weapon system. These models are characterized by their mathematical simplicity, moderate computer manipulation requirements, and ability to give a consistent overview of a specific question without attempting to explain the existence of a cost element or trying to optimize it. These models can also be used to predict operating and support cost of future weapon systems either by analogy with current weapon systems or introducing a value to a cost element that was developed from a type II model. Specifically the type I model gives values that are useful when:

[31] Weapon System Ownership Cost Modeling, Phase I Task 75-1. p. 19.

1. Comparing proposed and existing weapon systems.

2. Comparing a set of weapon systems.

3. Gauging a weapon system's cost with respect to the overall DOD budget.[32]

The type II models are those models that can be used to study a *segment of the ownership cost* of a weapon system. This segment could be the maintenance, inventory, or the transportation function, etc. of the weapon system. Often the model can reveal an alternative support strategy that is more desirable due to an existing functional strategy. The type II models are characterized by their mathematical complexity and considerable computer manipulation requirements. One reason why type II models are so numerous is that new weapon systems have unique requirements that must be analyzed differently than in previous systems. This results in numerous models being developed that analyze different aspects of a weapon system than did older models. This happens for just about every new weapon system developed. Table II gives an overview of 46 models utilized by the Armed Services and contractors in logistics planning. The table was compiled by the RAND Corporation in 1971 in an attempt to define the state-of-the-art of logistics models. Essentially, the type II model is a planning tool for constructing future systems and for improving existing ones. This is done by giving O & S cost estimates that may be sensitive to operating strategies and design concepts. Thus, this may allow for the optimization of the design and operations of both existing and proposed weapon systems. One other use that type II models have was mentioned above in describing the type I model.

[32] Ibid, p. 20.

TABLE II

OVERVIEW OF THE 46 MODELS [33]

Model	Source	Owner	Type	Language	Data Reqment	Application: Spares	ACF	Pers	LOR	Opns	LCC	Mgt	Comments
ABLE	Air Force Log Command	Air Force	Accounting	Joss,[a] Fortran	Minimal						x	x	Incentive oriented
AMSEC	Operations Res, Inc	Opns Res	Reliability	Fortran	Moderate	x	x	x		x	x		System reliability
ARMADA	Naval Weapons Systems Analysis Office	Navy	Simulation	Fortran, Simscript[b]	Much	x	x	x		x	x		
BDSM	General Dynamics	Gen. Dyn.	La Grange Mult	Fortran	Minimal	x							
BOMS	The Rand Corp	Air Force	Simulation	Simscript	Much	x		x		x			
CAEM	Lockheed Aircraft Corp	Lockheed	Simulation, Accounting	Fortran	Much					x	x		Transport aircraft
COAMP	Radio Corp of America	RCA	Network, Accounting	Fortran	Moderate	x	x		x		x		
DEQMAR	The Rand Corp	Air Force	Queueing	NP[c]	Minimal		x	x					
GEM	Naval Applied Sci Lab	Navy	Reliability, Differential Eq	Gem, Fortran						x			
LOSS	Lockheed Aircraft Corp	Lockheed	Simulation	Fortran	Moderate					x			Transport aircraft
LPM	General Dynamics	Gen. Dyn.	La Grange Mult	Fortran	Moderate	x							
LCCM	Planning Res Corp	RCA	Accounting	Simscript	Moderate						x	x	Costs by year
LCCP	Raytheon	Raytheon	Simulation, Accounting	Fortran, Cobol	Much	x	x	x	x	x	x		
LCOM	The Rand Corp	Air Force	Simulation	Simscript	Much	x	x	x	x	x			
LOGCOST	Air Force Log Command	Air Force	Accounting	Fortran	Minimal		x	x			x	x	Source selection
LORAM	Naval Air Syst Command	Air Force	Accounting	Fortran	Moderate	x	x		x		x		
MACOM	McDonnell Douglas	Air Force	Simulation	Simscript	Moderate					x			Missile countdown
MARIS	General Electric[d]	Navy	Simulation	Fortran	Much	x				x			
MCTAS	Lockheed Aircraft Corp	Lockheed	Simulation	GPSS	Much	x	x	x		x			System reliability
MEMM	General Electric[d]	Navy	Markov chain	Fortran	Moderate	x				x			
METRIC	The Rand Corp	Air Force	La Grange Mult	Fortran	Moderate	x							
MINE	The Rand Corp	Air Force	La Grange Mult	Fortran	Moderate	x				x			
MRSM	Lockheed Aircraft Corp	Lockheed	Simulation	GPSS	Moderate		x	x	x	x			Transport aircraft
OMLRS	Lockheed Aircraft Corp	Navy	Simulation	GPSS	Much	x	x	x		x			
ORLA	Air Force	Air Force	Accounting	Fortran	Minimal				x		x		
PLANET	The Rand Corp	Air Force	Simulation	Simscript	Much	x	x	x		x	x		
PROJMOD	The Rand Corp	Air Force	Differential Eq	NP	Moderate							x	Time/cost/performance
QUEST	The Rand Corp	Air Force	Probability, Accounting	Fortran	Moderate				x		x		
RAM	Naval Missile Center	Navy	Differential Eq	Fortran	Moderate							x	Resource allocation
RCM	Air Force Log Command	Air Force	Dynam Programming	Simscript	Moderate	x	x	x	x		x		
RMT	Air Force Inst of Tech	Air Force	Math Programming	Fortran	Moderate							x	R/M improvement
SAMSOM	The Rand Corp	Air Force	Simulation	Simscript	Much	x	x	x		x			
SCAM	The Rand Corp	Air Force	La Grange Mult, Accounting	Joss, Fortran	Minimal	x	x	x	x		x		
SCEET	McDonnell Douglas	Air Force	Accounting	Fortran	Moderate				x				
SCOPE	McDonnell Douglas	Air Force	Simulation	Simscript	Moderate					x			Missile flight
SCORE	Naval Air Dev Center	Navy	Accounting	Fortran	Moderate			x			x	x	Costs by year
SEEP	General Dynamics	Gen. Dyn.	La Grange Mult	Fortran	Minimal	x				x			
SEMERAT	The Rand Corp	Air Force	Queueing	Joss	Minimal		x	x		x			
SKEM	McDonnell Douglas	Air Force	Simulation	Fortran	Minimal	x							
SOCEM	The Rand Corp	Air Force	Markov Chain	Fortran	Minimal					x			Sortie analysis
SPAREM	General Dynamics	Gen. Dyn.	Simulation	Simscript	Moderate	x				x			
SPARTAN	The Rand Corp	Air Force	Network	Fortran	Moderate							x	Development sched
SPM	Lockheed Aircraft Corp	Lockheed	Algebraic	Cobol	Minimal	x							Transport aircraft
SSM	General Dynamics	Gen. Dyn.	Simulation	Simscript, Fortran	Moderate		x	x		x			
TRIM	Raytheon	Army	Accounting	Fortran, Cobol	Moderate	x	x		x		x		
VALUE	Martin Marietta Corp	Navy	Simulation	GPSS	Much	x	x	x		x	x		Aircraft carrier

[a] JOSS is the trademark and service mark of The Rand Corporation for its computer program and services using that program. [b] Simscript or Simscript I.5. Simscript I.5 is a trademark of Consolidated Analysis Center, Inc. [c] Not programmed. [d] Tempo Division.

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[33] "Using Logistics Models in System Design and Early Support Planning", Rand Report #R-550-PR, (February 1971), p. 50.

Type II models can be used to generate estimates for a cost element in the type I model. This is done by using CERs, regression analysis, or some averaging process over a known data base.

The remainder of this section on "Present Model Technology" will describe three operating and support cost models that are currently used by the Air Force. The first and second models, MACE and CAIG, are both type I models. The third model, LSC, is a type II model. All three models will be described by defining the cost equations of each and by explaining the overall purpose for each model. These three models will be used to formulate the Advanced RPV model in Chapter V.

Missile Annual Cost Estimating (MACE) Model.[34] The MACE model was developed to obtain "typical" strategic missile squadron operating and support costs and for cost effectiveness comparisons between weapon systems. This model was patterned after the Cost Analysis Cost Estimating (CACE) Model for aircraft. Certain changes were made to the CACE Model to allow for missile-unique operating costs. As previously mentioned, the MACE Model is a type I model that aggregated all the costs elements for a total weapon system operating and support cost. A listing of the cost elements is shown in Table III and an explanation of each cost element is presented in Appendix A.

[34] USAF Cost and Planning Factors (U), Cost Analysis, AFR 173-10, Volume 1, (6 February 1975).

TABLE III: MISSILE ANNUAL COST ESTIMATING MODEL (MACE)

Cost Elements

I. Recurring Investment & Miscellaneous Logistics

A: Peculiar Age
B: Maintenance-Missile
C: Depot Maintenance
D: Modification, Class IV (Inc. Initial Spares)
E: Replenishment Spares
F: Operational Missile Test & Analysis
G: Vehicular Equipment

II. Pay & Allowance (P & A)

H: Military
I: Civilians

III. BOS/RPM, Support of

J: PPE Manpower
K: BOS/RPM Manpower

IV. Medical, Support of

L: Officers
M: Airmen

V. Personnel Support

N: Permanent Change of Station-Officers
O: Permanent Change of Station-Airmen

VI. Pipeline Costs

P: Acquisition-Officers
Q: Acqusition-Airmen
R: Training-Officers
S: Training-Airmen

Cost Analysis Improvement Group (CAIG) Model.[35] The model developed by the Cost Analysis Improvement Group (CAIG) is a formal requirement for DSARC/DCP operating and support cost visibility. It is a typical type I model that gives an account of the existing system principally based on factors which relate to historical costs of comparable systems. A useful characteristic of this model is that it takes into account the uncertainties in future O & S costs by presenting the costs as ranges of estimates. The model is a summation of 24 cost elements as shown in Table IV. An explanation of each cost element is given in Appendix B.

Logistics Support Cost (LSC) Model.[36] The LSC model is a type II model that is used to estimate the expected support cost that may be incurred by selecting a specific design. The model is used to compare and discriminate among alternative designs where the relative difference in cost is the prime measure of selection. Thus, the most important aspect of the LSC model estimates is the magnitude of the cost difference between two design alternatives. The model is made up of ten equations, each representing a specific resource cost required to operate the given logistics system. Then the model sums up these equations to give the expected major resource costs associated with the logistics experienced during operation and maintenance. Table V summarizes the ten cost elements and Appendix C defines each element as given in the LSC Model User's Handbook.

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[35] Operating and Support Cost Estimates--Aircraft Systems Cost Development Guide, Defense Systems Acquisitions Review Council, (May 1974).

[36] Logistics Support Cost Model User's Handbook, (January 1974).

TABLE IV

COST ANALYSIS IMPROVEMENT GROUP MODEL (CAIG)

Cost Elements

I. Squadron Operations

A: Combat Command Staff Manpower
B: Aircrew Manpower
C: Base Aircraft Maintenance Manpower
D: Base Munitions Maintenance Manpower
E: Aircraft Security Manpower
F: Aviation POL
G: Base Aircraft Maintenance Materiel
H: Miscellaneous Personnel Support

II. Base Operating Support

I: Base Services Manpower
J: Miscellaneous Personnel Support

III. Logistics Support

K: Depot Maintenance Manpower and Materiel
L: Supply Depot Manpower and Materiel
M: Second Destination Transportation

IV. Personnel Support

N: Recruit/Technical Training Manpower
O: Undergraduate Pilot/Navigator Training
P: Medical Manpower
Q: Medical Materiel
R: Permanent Change of Station (PCS)
S: Miscellaneous Personnel Support

V. Recurring Investment

T: Replenishment Spares
U: Recurring (Class IV) Modifications
V: Common Aircraft Ground Equipment
W: Training Munitions
X: Training Missiles

TABLE V

LOGISTICS SUPPORT COST MODEL (LSC)

Cost Elements

1. Initial & Replacement Spares Cost
2. On-Equipment Maintenance Cost
3. Off-Equipment Maintenance Cost
4. Inventory Entry & Supply Management Cost
5. Cost of Support Equipment (Age)
6. Cost of Personnel Training & Training Equipment
7. Cost of Management & Technical Data
8. Cost of New Facilities
9. Cost of Fuel
10. Cost of Spare Engines

Comparison of Cost Models

A comparison of the MACE and DSARC/CAIG models reveals that they are similar enough to be capable of giving comparable estimates of operating costs. The principle differences between the two models are the following:

1. Personnel in the primary program element are grouped differently in the two models.
2. The DSARC/CAIG model explicitly includes depot maintenance manpower and materiel, supply depot maintenance manpower and material, and second destination transportation as part of the logistics costs. The MACE model uses a non-flying hour factor to estimate depot maintenance costs. It is not clear whether the MACE factors include the same elements as are explicitly included in the DSARC/CAIG model.
3. In the planning additives, the MACE model includes a term for vehicular and other support costs.

The LSC model provides greater detail in its estimation of maintenance related costs than does either the MACE or the DSARC/CAIG model. This is both by virtue of its breakout to the line replaceable unit (LRU) level and its more detailed breakout of maintenance cost categories. It is noted that the LSC model combines fixed investment costs with recurring costs. It further breaks these down into personnel and material costs, and separates costs at the organizational, intermediate, and depot levels.[37] Before proceeding into the development of a squadron concept in which to apply the above findings, there are several weapon system characteristics that should be defined.

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[37] Life Cycle Cost Analysis Support (Phase I) for Compass Cope, (April 1975) p. 4.

Definition of Weapon System Characteristics

There are certain fundamental concepts and relationships that should be established before a reasonable squadron concept for the Advanced RPV can be developed. These concepts and relationships form the basis upon which the operations and maintenance policies will be formulated in chapter IV. Each of these concepts will be defined and discussed in relation to the way they will be applied in the squadron concept. What follows is one way to describe these fundamental concepts and relationships.

Design Adequacy

"System design adequacy is the probability that a system will successfully accomplish its mission, given that the system is operating within design specifications."[38] The probability itself is a function of such variables as system accuracy under the conditions of use, the mission to be accomplished, the design limits, system inputs, and the influence of the operator. The important implication of this concept for the ARPV is that the vehicle will be designed for multiple missions (i.e. Reconnaissance, Electronic Warfare, and strike). This requirement will necessitate tradeoffs in performance requirements for the different missions. The compromise in performance requirements may cause the final design of the ARPV to have an increased probability of mission failure for any one or all of the mission profiles.

Reliability

"Reliability is the probability that a system will perform

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[38] Weapons Guidance Labortory Reliability Training Program, ARINC Research Corporation, AF 33(600)-40259, (November 15 - December 15, 1960), p. 1-8.

satisfactorily for at least a given period of time when used under stated conditions."[39] Thus, reliability relates to the frequency with which failures occur. Here failure means unsatisfactory performance as determined by an operator or a maintenance man. This reliability term refers to the system or a piece of equipment. Another term, called Mission Reliability, is defined as "the probability that the system will operate in the mode for which it was designed for the duration of a mission, given that it was operating in this mode at the beginning of the mission."[40] Mission reliability thus defines the probability of non-failure of the ARPV for the period of time required to complete a mission. The probability is expressed as a point on the reliability function corresponding to a time equal to the mission length.

Maintainability

"Maintainability is defined as the probability that a failed system is restored to operable condition within a specified total down time."[41] This concept can be influenced by the following: 1) the ability to isolate a failure to the removable unit or to an on-equipment action at the flight line, 2) the accessibility of equipment, 3) the removal and replacement operations, 4) the queueing for maintenance and spares, 5) the reliability of AGE, 6) the adequacy of technical data, and 7) the skill levels of personnel.

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[39] Ibid, p. 1-7.

[40] Ibid.

[41] Ibid, p. 1-10.

Down Time

"Down time is the total time during which the system is not in acceptable operating condition."[42] This concept can be subdivided, as shown in figure 3, into the following:

1. Active Repair Time: that portion of down time during which one or more technicians are working on the system to effect a repair.
2. Logistic Time: that portion of down time during which repair is delayed solely because it is necessary to wait for a replacement part from another subdivision of the logistics system.
3. Administrative Time: that portion of down time not included under active repair time and logistic time.[43]

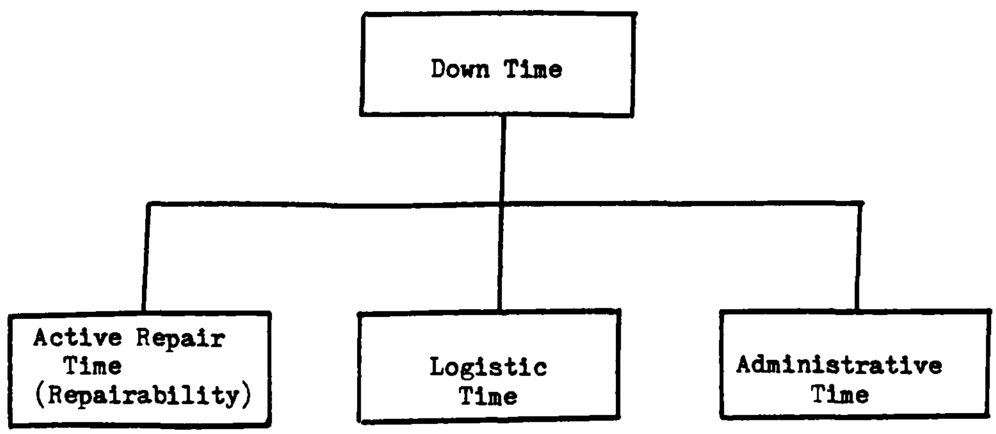

Figure 3. Subdivisions of Down Time[44]

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[42] Ibid, p. 1-14.

[43] Ibid.

[44] Ibid, p. 1-16.

Availability

"The availability of a system or equipment is the probability that it is operating satisfactorily at any point in time when used under stated conditions, where the total time considered includes operating time, active repair time, administrative time, and logistic time."[45] This concept is different from operational readiness in the categories of time that are included, as shown in figure 4.

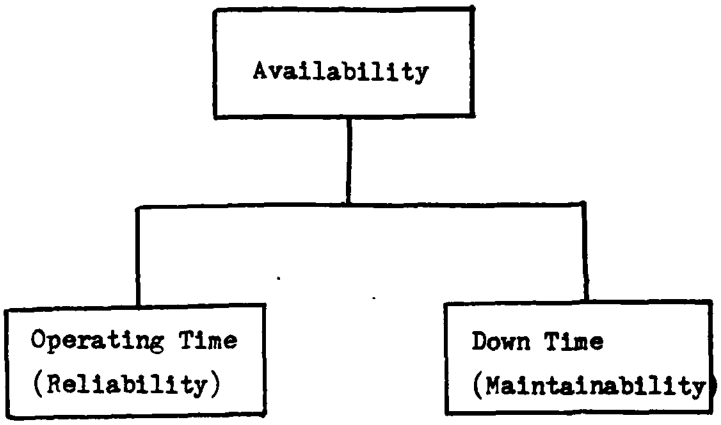

Figure 4. Subdivisions of Availability[46]

Operational Readiness

"The operational readiness of a system or equipment is the probability that at any point in time it is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions, including stated allowable warning time."[47] Thus, total calendar time is the basis for computation of operational readiness.

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[45] Ibid, p. 1-8.

[46] Ibid, p. 1-16.

[47] Ibid, p. 1-8.

This concept differs from availability in that operational readiness as shown in figure 5, includes both free time and storage time. "Free time is the time during which operational use of the system is not required. This time may or may not be down time, depending on whether or not the system is in operable condition. Storage time is the time during which the system is presumed to be in operable condition, but is being held for emergency--ie., as a spare."[48]

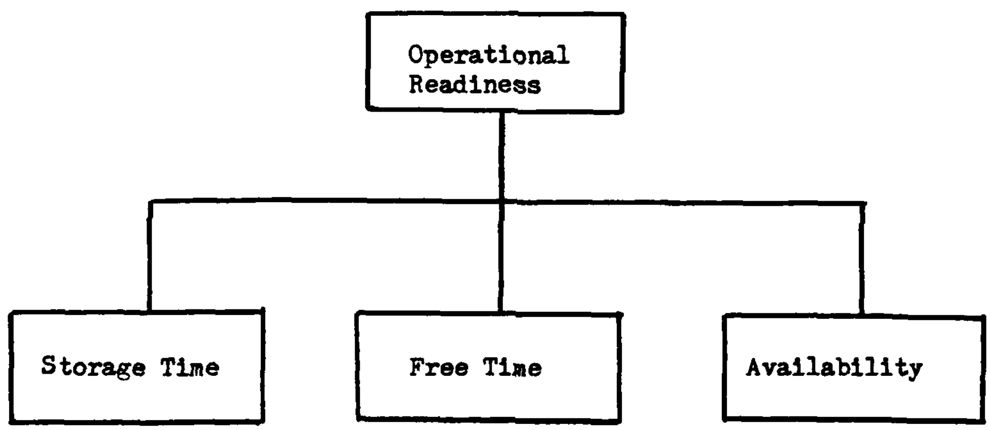

Figure 5. Subdivisions of Operational Readiness[49]

System Effectiveness

"System effectiveness is the probability that the system can successfully meet an operational demand within a given time when operated under specified conditions."[50] It is shown in figure 6 that effectiveness is influenced by the way the equipment was designed and built. However,

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[48]Ibid, p. 1-5.

[49]Ibid, p. 1-16.

[50]Ibid, p. 1-5.

just as important are the ways the equipment is used and maintained. In other words, system effectiveness can be materially influenced by the design engineer, the production engineer, the operator, and the maintenance man. It can also be influenced by the logistic system that supports the operation, and by the administration through personnel policy, rules governing equipment use, fiscal control, and many other administrative policy decisions.

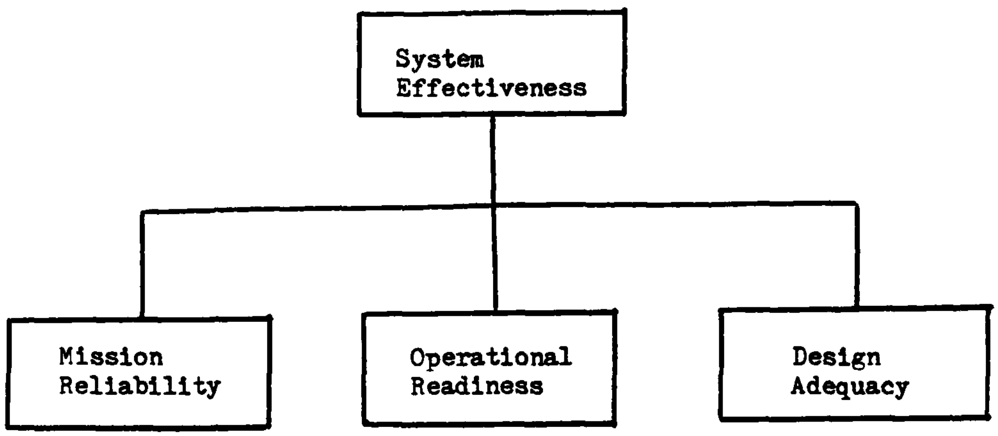


Figure 6. Subdivisions of System Effectiveness[51]

In figure 7, which follows on the next page, the concepts and relationships described in this last section are summarized.

[51] Ibid, p. 1-16.

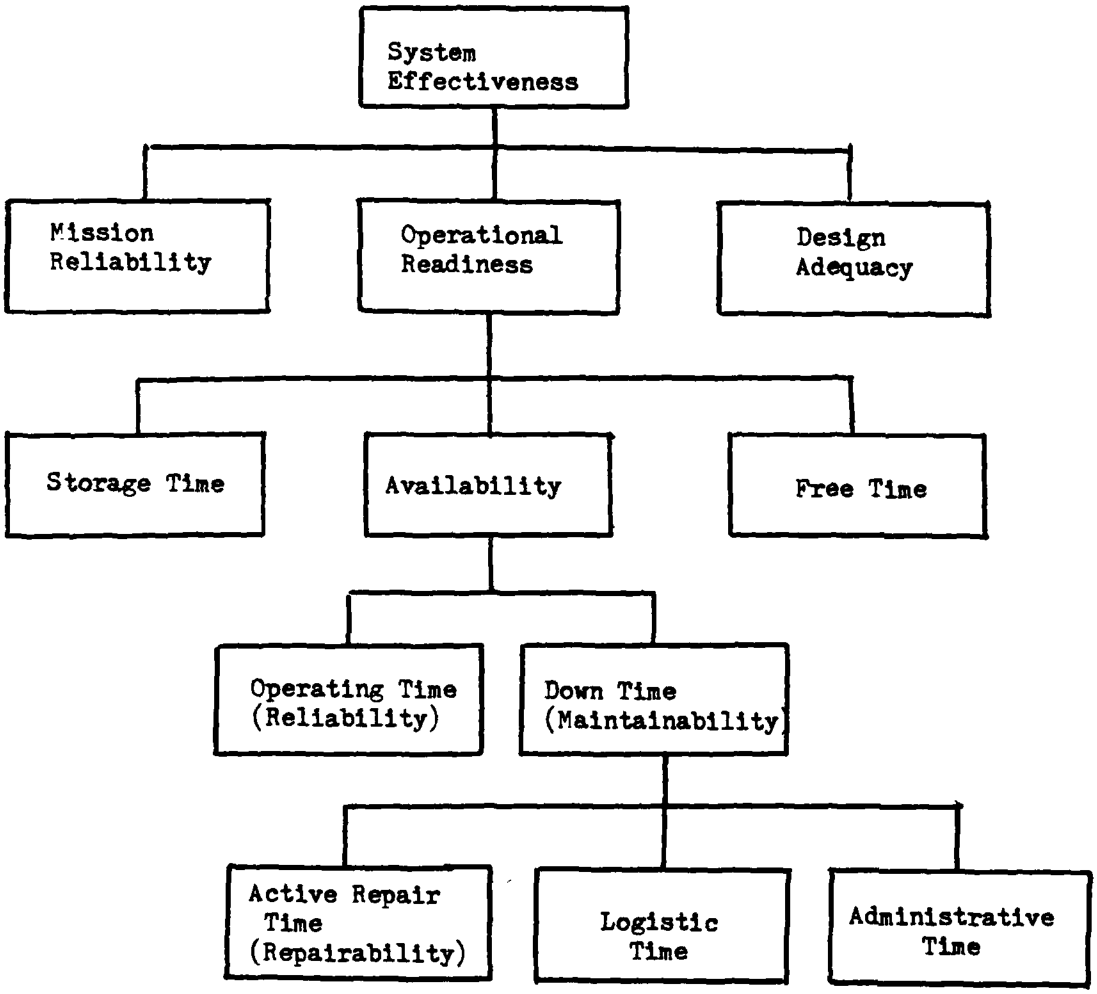


Figure 7. System Effectiveness Tree[52]

[52] *Ibid.*

Summary

Chapter III presented the background of information on current operating and support cost technology that will be used to develop an ARPV squadron concept and O & S cost model. The present status of O & S cost estimating was discussed in light of the increasing cost consciousnous of Congress and the Department of Defense. Next, the difficulty of preparing accurate O & S cost estimates was examined. This was attributed primarily to the lack of a formal data collection system that collected O & S cost data by specific weapon system. Then some current modeling techniques were described, along with three current cost models which are used by the Department of Defense. These were the MACE, CAIG, and LSC Models. In the final section, several fundamental concepts and relationships were given to aid in describing a weapon system. These concepts were design adequacy, reliability, maintainability, down time, availability, operational readiness and system effectiveness. These will be used in chapter IV to develop an ARPV squadron concept.

CHAPTER IV: ADVANCED REMOTELY PILOTED VEHICLE (ARPV) SQUADRON CONCEPT

This chapter will present a conceptual view of an Advanced Remotely Piloted Vehicle (ARPV) Squadron. Specific areas that will be discussed are 1) basing assumptions, 2) squadron structure, 3) mission profiles, 4) ARPV subsystems, 5) operations concept, 6) maintenance concept, and 7) personnel and training requirements. The information developed in this chapter will be used in developing and analyzing the ARPV Operating and Support (O & S) cost model presented in Chapter V. The primary sources of information used to develop the above areas are from contract proposals and studies by industry, from the ARPV program manager and other RPV program office personnel, and from four years of experience received by this writer on a Strategic Air Command (SAC) Titan II missile crew.

Basing Assumptions

The ARPV Squadrons will be deployed primarily in Europe at three bases facing the Warsaw Pact nations. These bases will provide the essential support functions required to maintain the operational units. The operational activities such as command and control, launch, and recovery will take place some distance away from the bases and at a specified distance from the forward edge of the battle area (FEBA). The respective bases would house the squadron personnel and maintenance facilities. In addition, a fourth base, located in the continental United States, would be used primarily as a training base for all ARPV Squadron personnel. This means that all personnel assigned to an ARPV squadron in Europe would be trained first at the base located in the United States. Also, Air Force reserve units would be trained there in ARPV operations so that these units could be flown to Europe as reinforcements should an emergency arise.

Squadron Structure

The structure of the ARPV Squadron should be designed to optimize the number of persannel required, while at the same time, ensuring that its capability to perform its functions is maintained at an acceptable level. The basic structure should consist of an operations division and a maintenance division. This ARPV Squadron structure would include, as a minimum, the units named in figure 8.

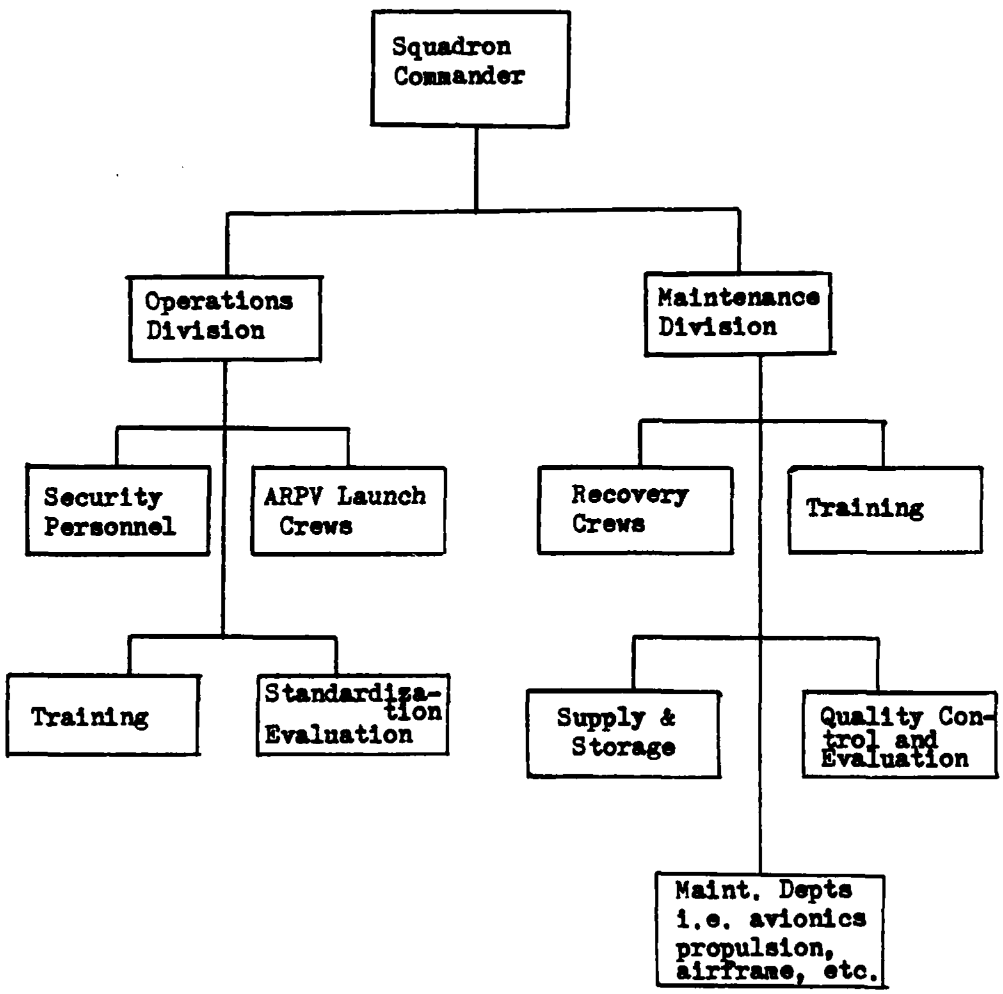


Figure 8. ARPV Squadron Structure

Mission Profiles

The ARPV Squadron will be required to maintain the capability to fly three distinct mission profiles. These are the reconnaissance, electronic warfare (EW), and the strike missions. For this study, each mission profile will account for one-third of the assigned missions. That is, one-third of the assigned ARPVs will be flown on reconnaissance missions, one-third of the assigned ARPVs will be flown on EW missions, and the remaining one-third will be flown on strike missions. This assumption was made with the concurrence of the ARPV program manager in order to simplify the O & S cost model and at the same time consider the three distinct mission profiles.

The reconnaissance missions will be flown to locate and evaluate enemy positions and capabilities and to assess battle damage. The EW missions will provide communications jamming and signal interceptions. The strike mission will provide the capability to seek out a target, evade defenses, and destroy enemy targets.

Advanced RPV Description

This section describes a concept for the ARPV and illustrates this concept by several figures designed by various contractors who have been doing conceptual studies on the ARPV. The concept consists of the airframe, the propulsion, and the avionics subsystems. In figure 9, an illustration of the ARPV is shown. A modular design feature is presented that will enable rapid replacement of components and allow for remote repair of these components. The illustration also shows a removable engine that is easily accessible for on vehicle maintenance and adjustments. In figure 10, the avionics compartment design demonstrates a concept that enables rapid replacement and

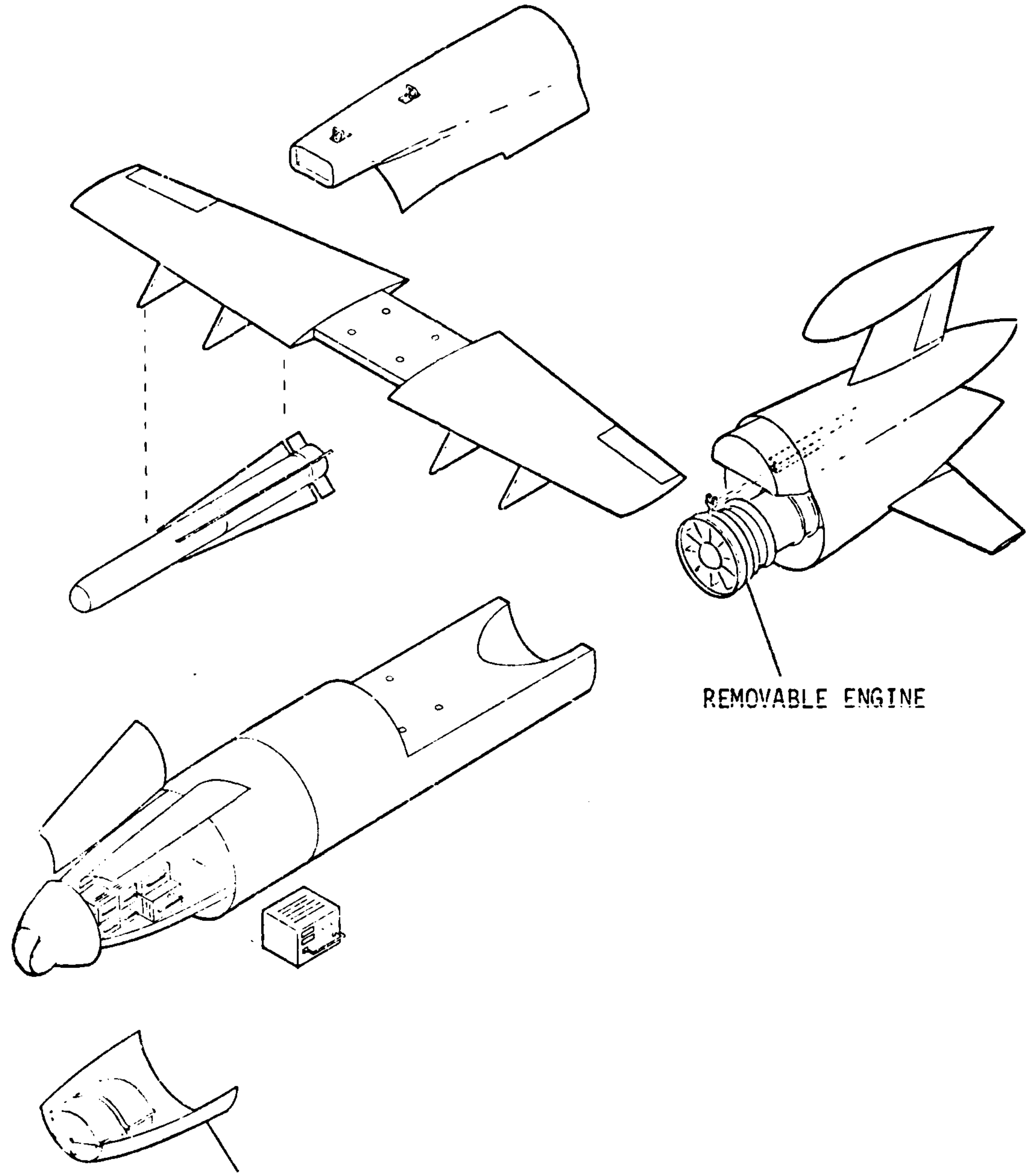
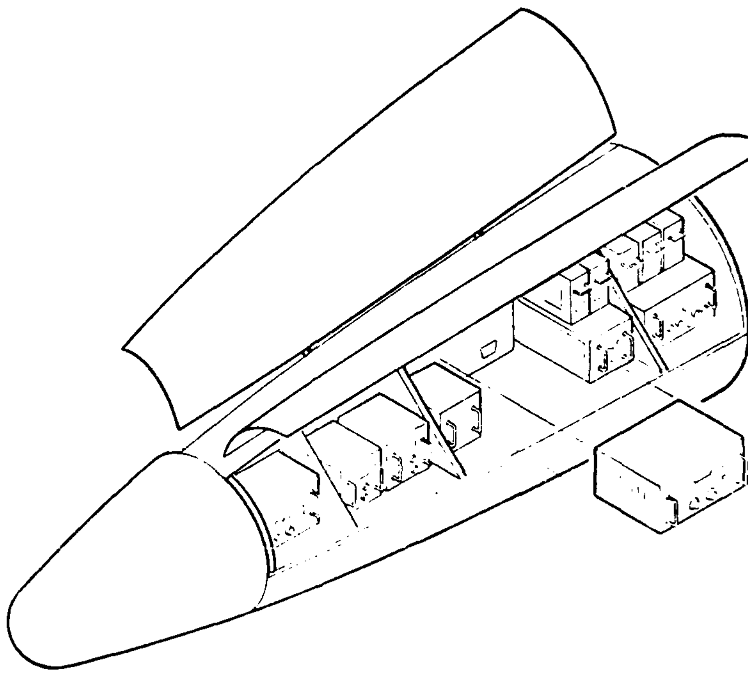


Figure 9. Advanced RPV Mockup Concept[53]

[53] Conceptual Phase Proposal for the Advanced RPV, Northrop Corporation; Ventura Division, (February 1975), p. 3-37.

reconfiguration of equipment. Specific design characteristics of the avionics compartment are one-deep line replaceable units (LRU), slide in/out standard boxes, rack and panel connectors, and generous amount of accessible handles.



- o One-Deep LRUs
- o Slide In/Out Standard Boxes
- o Rack and Panel Connectors
- o Generous Handles

Figure 10. ARPV Design Concept[54]

The basic design of the ARPV contributes to the ease and speed of performing maintenance on the vehicle. Figure 11 summarizes some of the maintainability design features that the ARPV would have with the above design concept. A maintenance benefit is then described for each subsystem design feature.

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[54] Ibid, p. 3-171.

FEATURE	MAINTENANCE BENEFIT
<u>AIRFRAME</u>	
Modular Design	Line Replaceable Units Emphasized. Rapid Component Replacement. Remote Repair of Components.
Access for X-Ray, Boroscope and Chemical Nondestructive Inspection.	Positive Structural Integrity determination. Minimal Disassembly required.
Sized, Quick Opening, Ground-Level Panels and Doors	Better inspections, easier on aircraft maintenance. Reduced removals for access. Minimal age.
Single Tridair-Type, Quick Opening Fasteners and Latches.	Rapid Access. Reduced Fastener/Latch Spares. Easy Fastener Replacement and Repair.
Sub-Door Panels in Large Panels and Doors.	Reduce Need to Open Large Doors and Stress Panels.
Equipment Placement Dispersal for Concurrent Maintenance.	Simultaneous Maintenance, Minimum Interference.
<u>AVIONICS</u>	
Palletized Mission Equipment	Rapid Replacement and Reconfiguration.
Replaceable Units	Shop Precalibrated. Rapid On-Aircraft Repair.
Ground-Level Access	Reduced Age.
One-Deep Installation.	Reduced Removals for Access.
Built-In Test Equipment (BITE)	Rapid Fault Isolation.
Slide Rack Mounted.	Immediate Accessibility
Plug-In Connections.	Irreversible Connections.

Figure 11

Maintainability Design Features[55]

[55] <u>Ibid</u>, p. 3-169.

Operations Concept

The operational concept is developed from the baseline assumptions made by this writer for the ARPV Squadrons. These baseline assumptions are the following:

1) The total force of ARPVs will number 450. These will be located at three bases in Europe and one base in the United States. The distribution of ARPVs will be 135 vehicles at each European base and 45 at the U. S. base.

2) Each European base will maintain 50 ARPVs in various stages of operational readiness. Four ARPVs will be ready for launch within one hour of notification. These vehicles will be maintained at the launch area and monitored by the launch crew in a control center. An additional eight ARPVs will be ready for launch at three hours after initial notification. The remaining 38 will be ready for launch within 24 hours of initial notification.

3) The remaining 85 ARPVs, located at each base, will be disassembled and stored for future use. These ARPVs will be required to be operationally ready for launch within 72 hours of initial alert notification. Within this 72 hours, an additional contingent of 15 vehicles will be flown in from the United States for a total ARPV force of 150 vehicles at each European base.

4) The total number of personnel at each European base will be sufficient to maintain the operational requirements of the first group of 50 ARPVs. After an alert notification, additional personnel from the base in the United States would be flown-in within 72 hours. Most of these additional personnel would be Air Force reservists called to active duty for that alert situation. Total personnel would then be capable of maintaining the force of 150 ARPVs for an indefinite period.

5) There would be four ARPVs maintained at the launch area at all times. Each of these vehicles would be on launch pad alert for two weeks. A schedule would be made whereby two new ARPVs would be rotated onto launch pad alert every week. The two new ARPVs that were replaced would be moved to an auxillary launch area and flown on a training mission. The total number of training missions would be eight per month and about 50 per six month period. Thus, the entire group of ARPVs in ready storage (50 vehicles) would be on launch pad alert four weeks per year and would be flown on training missions twice per year. These training missions would enhance both the capability of the launch crews and the reliability of the vehicles.

6) Launch and recovery procedures would be carried out in a location close to the FEBA. Launch control would be maintained by a crew on duty at all times in a mission control center (MCC). Additional mobil MCCs could be provided in an alert situation. A launch and a recovery area would be close together to facilitate the turnaround times of the ARPVs.

Maintenance Concept

For the purpose of this thesis, the maintenance concept for the ARPV is based upon the following assumptions:

1) Each base will have the capability to perform maintenance on the vehicles at the launch and recovery areas. This maintenance will include servicing, checkout, and inspection of systems prior to launching the vehicles. This capability includes ARPVs that are on alert and those ARPVs that have recently been recovered and are required to be relaunched.

2) The ARPV will be designed with ease of maintenance in mind. Various subsystems such as engines, avionics, and airframe components will be capable of changeout in a more timely manner than was the case with past weapon systems. The design concept of modularity will be used throughout

the ARPV's avionics and ground support equipment to reduce on-vehicle maintenance and optimize total turnaround cycle cost.

3) The maintenance depot will be located in the United States and will provide all necessary depot functions for all four operating bases.

4) Organizational level maintenance will develop a preventive maintenance approach for the entire inventory of ARPVs. This will include the operational vehicles and the disassembled vehicles maintained in storage locations on each base.

The above assumptions are illustrated in Figure 12 where the sequence of maintenance functions is shown that must be performed in order to prepare the recovered ARPV for relaunch. This turnaround cycle is critical to the effectiveness of the ARPV system. It involves many trade-offs in the initial system design to minimize time lines and maintenance costs. For this thesis, it is assumed that the requirement for minimum turnaround time and the cost of hardware and software have been optimized. In Figure 13, the ground function flow is shown that the ARPV follows when it is recovered and recycled for launch.

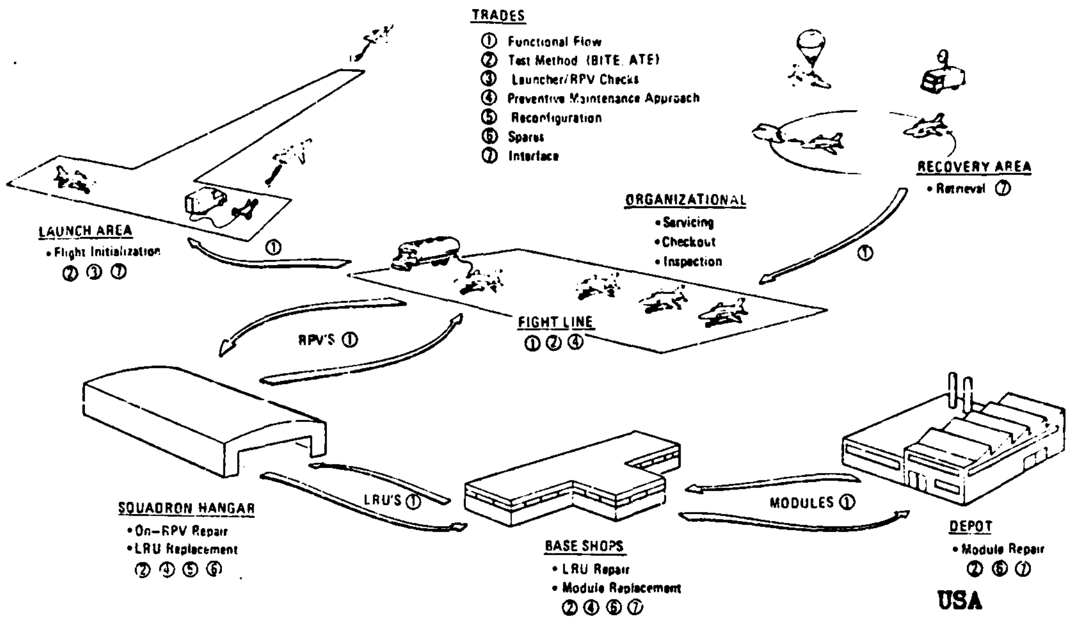

Figure 12. The Turnaround Cycle[56]

[56] Advanced RPV Conceptual Phase Proposal, Teledyne Ryan Aeronautical, (February 1975), p. F-129.

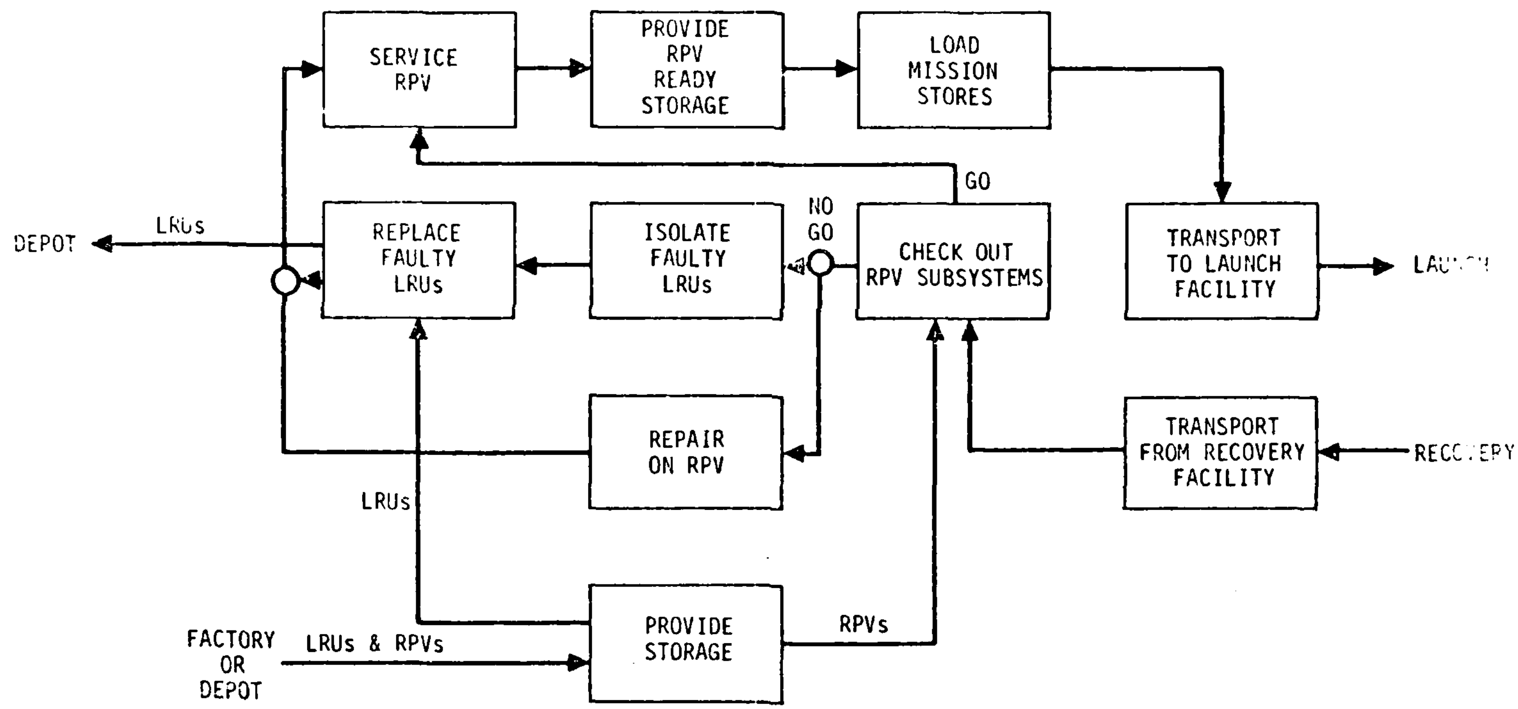

Figure 13. Ground Function Flow[57]

[57]Conceptual Phase Proposal for the Advanced RPV, Northrop Corporation, Ventura Division, (February 1975), p. 3-166.

Personnel and Training

This section will develop the personnel and training requirements for the ARPV Squadron. First, the crew composition and crew ratio will be presented and then the maintenance manpower requirements will be developed. Before going further, an explanation of the assumed policy on personnel costs for the ARPV Squadron will be given.

A major part of the operating and support costs of the ARPV will be the costs attributed to personnel. In Figure 14, Life Cycle Costs are given in which total costs of developing, acquiring, operating and supporting candidate ARPV systems can be compared. Column II shows a system in which minimum acquisition costs were pursued causing increased maintenance and personnel costs. Column I shows that lower Life Cycle Costs were obtained through lesser use of personnel, higher acquisition costs through higher equipment reliability, and lower maintenance cost through higher maintainability of the systems. For this thesis the ARPV system represented in column I was assumed.

The following baseline assumptions for personnel requirements are made:

1) The ARPV crew is composed of:

   Senior Controller (officer)
   Deputy Controller (officer)
   Guidance Technician (airman)
   Communications Technician (airman)

2) Total number of alert hours assigned to crews per month:

   $$\frac{24 \text{ hours} \times 365 \text{ days}}{12 \text{ months/per year}} = 730 \text{ hours/month}$$

   Requirement exists for a primary crew and a standby crew to be assigned for each 24 hour period.

   one primary crew = one standby crew = 2 x 730 hours/month = 1460 hours/month

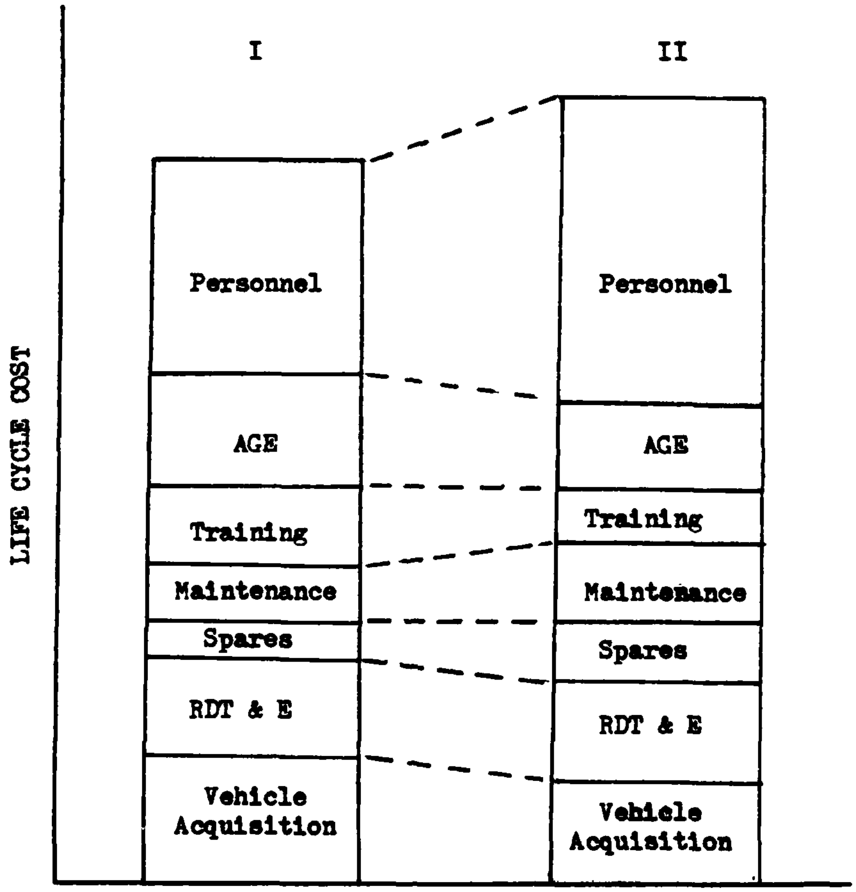

Figure 14. Comparison of Alternate Systems[58]

[58] Advanced RPV Conceptual Phase Proposal, Teledyne Ryan Aeronautical, (February 1975), p. A-17.

3) Ground alert duty for each crew per month:

5 primary alerts (24 hours/alert)	=	120 hours
1 standby alert (24 hours/alert)	=	24 hours
Simulator Training	=	3 hours
System Training (classroom)	=	3 hours
Non-crew duty	=	10 hours
Total	=	160 hours/month

4) Total number of crews:

$$\frac{\text{1460 alert hours assigned}}{\text{144 crew alert hours/month}} = 10.14 \text{ or approximately 11 crews}$$

11 crews for line duty
2 Standardization Crews
2 Instructor Crews

15 Total crews

2 officer/crew x 15 = 30
2 airmen/crew x 15 = 30

Total personnel = 60

5) Crew Ratio per ARPV:

$$\frac{\text{15 crews}}{\text{50 ARPVs}} = .3 \text{ crews per ARPV}$$

6) Total Maintenance Manpower:

(a) Productive manhour requirement:

(50 ARPV/Squadron) x (60 Wartime sorties/month)[59] x (2 flying hours/wartime sortie)[60] x (3 maintenance M.H./flying hours)[61] x (1.15 add-on percentage for maintenance of ARPV ground equipment)[62] x (1.10 add-on percentage for maintenance supervision)[63] = 22,770 man hours

(b) Maintenance personnel requirement:

$$\frac{22{,}770}{145.2 \text{ available manhours/man/month}} = 157 \text{ personnel}$$

157 x .02 officer% = 3 maintenance officers

157 x .98 airmen % = 154 maintenance airmen

7) Total Military Manpower

10 Combat Command Officers
20 Combat Command Airmen
30 ARPV Crew Officers
30 ARPV Crew Airmen
3 Maintenance Officers
154 Maintenance Airmen
2 Munitions Maintenance Officers
43 Munitions Maintenance Airmen
24 Security Police Airmen

316 Total Military Personnel

[59] Estimates derived from discussion with ARPV program personnel.

[60] Ibid.

[61] Ibid.

[62] Operating and Support Cost Estimates--Aircraft Systems Cost Development Guide, Defense Systems Acquisitions Review Council, (May 1974), p. 31.

[63] Ibid.

Summary

This chapter presented an Advanced RPV Squadron concept upon which an Operating and Support Cost model will be developed. The areas that were discussed were 1) basing assumptions, 2) squadron structure, 3) mission profiles, 4) ARPV subsystems, 5) operations concept, 6) maintenance concept, and 7) personnel and training requirements. Several crew and maintenance manpower estimates along with total military manpower estimates were derived for use in the model to be presented in Chapter V.

CHAPTER V: ADVANCED REMOTELY PILOTED VEHICLE OPERATING AND SUPPORT COST MODEL

This chpater will present an Operating and Support (O & S) Cost model for the Advanced Remotely Piloted Vehicle (ARPV). The purpose for this model is to provide ARPV program personnel with an analytical tool to aid in management decision making. The total O & S costs derived from this model are not significant by themselves. This is because the values used for the input variables do not have a high degree of accuracy at this point in the acquisition phase. Only the relative O & S costs for alternative design concepts are significant. By analyzing how changes in cost variables affect the total O & S costs for a design concept, the manager can identify the high cost drivers and take the necessary steps to minimize their impact. In the second part of chapter V, an analysis will be made of four O & S cost model variables that have a significant impact on total O & S costs of the ARPV squadron. Then, the last part of the chapter will discuss the significance of the cost model.

Operating and Support Cost Model

The Operating and Support Cost Model presented in this chapter is a composite of the significant cost elements found in the Missile Annual Cost Estimating (MACE) model, the Cost Analysis Improvement Group (CAIG) model, and the Logistics Support Cost (LSC) model. There were several reasons for choosing these models. First, all three models are recognized as valid cost models and are being used in various programs in the Air Force. Second, the ARPV squadron concept in this study has some similarity to an aircraft squadron and also to a missile squadron. Therefore, the CAIG model for aircraft and the MACE model for missiles were chosen to select the applicable cost elements. Next, the LSC model was chosen because it provides insight into the logistics

variables that aggregate up to the top level support costs. This visibility of support cost variables is desired in order to demonstrate how some logistics support cost variables impact total O & S costs for an ARPV squadron. Also, it is the intention of this writer that the O & S cost model could be used for trade off studies to reduce ARPV life cycle costs.

The O & S cost model consists of 24 cost elements that are grouped into five areas, similar to the CAIG model (see Table VI). These areas are Squadron Operations, Base Operating Support, Logistics Support, Personnel Support, and Recurring Investment. In the next section, a short description of each of the 24 cost elements will be given along with an equation that identifies the cost variables that make up the cost elements. There is, also, included an estimate for each variable that will be used in a demonstration of the sensitivity of the total O & S costs to selected cost variables. Some of the estimates are taken from Air Force Regulation 173-10, <u>USAF Cost and Planning Factors</u>. Others come from the <u>Operating and Support Cost Estimates Guide</u> and the <u>Logistics Support Cost Model User's Handbook</u>. The remaining cost estimates were developed in chapter IV and reflect this writer's best estimate. The O & S costs are developed for a one year period and then expanded to a total O & S costs for a 15 year weapon system life cycle.[64] All estimates are expressed in constant FY 75 dollars.

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[64] <u>Ibid</u>, p. 8.

TABLE VI

ARPV OPERATING AND SUPPORT (O & S) COST MODEL

COST ELEMENTS AND SOURCES

	MACE	CAIG	LSC
A. Squadron Operations:			
1. Combat Command Staff Manpower		x	
2. ARPV Crew Manpower	x	x	
3. Base Munitions Maintenance Manpower		x	
4. ARPV Security Manpower		x	
5. Fuel Consumption	x	x	x
6. Miscellaneous Personnel Support	x	x	
B. Base Operating Support:			
7. Base Services Manpower	x	x	
8. Miscellaneous Personnel Support	x	x	
C. Logistics Support:			
9. On-Equipment Maintenance Cost			x
10. Off-Equipment Maintenance Cost			x
11. Inventory Entry and Supply Management Cost ...			x
12. Cost of Management and Technical Data			x
13. Cost of Spare Engines	x		x
D. Personnel Support:			
14. Recruit/Technical Training Manpower	x	x	
15. ARPV Crew Training Cost	x	x	
16. Medical Manpower	x	x	
17. Medical Material	x	x	
18. Permanent Change of Station (PCS)	x	x	
19. Miscellaneous Personnel Support		x	
E. Recurring Investment:			
20. Initial and Replacement LRU Spares Cost			x
21. Recurring Modifications (Class IV)	x	x	
22. Cost of Support Equipment (AGE)	x		x
23. Training Munitions		x	
24. Training Missiles		x	

NOTE: Some cost element equations were influenced by more than one model.

A. Squadron Operations: This includes all the necessary activities for the direct accomplishment of the unit's **mission.**

1) Combat Command Staff Manpower: The cost of paying the personnel required for operator supervision. These personnel perform such jobs as command, operations control, planning and scheduling, ARPV safety, quality control on crew training and controller proficiency. **This** cludes the combat commander, his staff, and the squadron commanders and their respective staff.

$$= \sum_{i=1}^{3} (CSM_i)\ (C_i), \quad i = 1\ (\text{Off}),\ 2\ (\text{Air}),\ 3\ (\text{Civ})$$

Where:

CSM = Number of personnel per squadron assigned to command staff duties.

(10 officers; 20 airmen; 1 civilian)

C = cost per man

(officers: $20,224; airmen: $9,110; civilian: $12,995)[65]

2) ARPV Crew Manpower: The cost of paying the full complement of crews required to man unit mission control centers (MCC). This includes all of the crews necessary for the efficient operation of the unit in meeting combat readiness requirements; training requirements; and administrative requirements such as leave, sickness, TDY, etc.

$$= (UE)\ (CUE) \sum_{i=1}^{2} (MC_i)\ (C_i), \quad i = 1\ (\text{Off}),\ 2\ (\text{Air})$$

Where:

UE = Units of ARPVs

(50)

[65] USAF Cost and Planning Factors (U), Cost Analysis, AFR 173-10, Volume 1, (6 February 1975).

CUE = Crews per UE

(.3)

MC = Men per Crew

(4: two officers, two airmen)

C = Cost per man

3) Base Munitions Maintenance Manpower: The cost of paying personnel needed for: loading, unloading, arming and dearming of squadron munitions; inspection, testing and maintenance of all ARPV weapons release systems; maintenance, ammunition loading, activation and deactivation of aircraft gun systems; and maintenance and handling of the munitions stockpile authorized.

$$= (UE)\ (MUE)\ (C)$$

Where:

UE = Units of ARPVs (15 approximately one-third ARPVs used for Strike missions)

MUE = Men per UE (3: three airmen)

C = Cost per man

4) ARPV Security Manpower: The cost of paying personnel needed for ARPV equipment security: For example, entry control, close and distant boundary support, and security alert teams.

$$= \sum_{i=1}^{2} (MS_i)\ (C_i),\ i = 1\ (\text{Off}),\ 2\ (\text{Air})$$

Where:

MS = Number of men assigned to squadron security for the ARPVs. (24: 1 officer; 23 enlisted)

C = Cost per man

5) Fuel Consumption: The cost of fuel for the operational life of the ARPV system.

$$= (TFFH)\ (FR)\ (FC)$$

Where:

TFFH = Expected total force flying hours over the program Inventory Usage period. (200 hours per year)

FR = Fuel consumption rate in units/flying-hours. (370 gallons/per flying hour)

FC = Fuel cost/unit. (.373 per gallon)

6) Miscellaneous Personnel Support: The cost of supplies, services and equipment needed to support ARPV unit personnel. This includes administrative supply items, expendable equipment and office machines, custodial services and other personnel-oriented support items (desks, chairs, etc.).

$$= (TSM)\ (SC)\ (TSP)$$

Where:

TSM = Total number of personnel assigned to squadron. (316; includes maintenance men)

SC = Support cost per man. ($790)

TSP = Support percentage attributed to squadron personnel. (.15)

B. Base Operating Support: This includes all the support activities performed by base personnel to directly support squadron operations.

7) Base Services Manpower: The cost of paying those base personnel necessary to directly support squadron personnel including activities such as food service, supply, motor pool and payroll operations. The

sum of these costs represent the pay of those base people who would leave the base if the operating requirement were to more elsewhere.

$$= \sum_{i=1}^{3} (TSM_i)\ (BMP_i)\ (C_i),\ i = 1\ (\text{Off}),\ 2\ (\text{Air}),\ 3\ (\text{Civ})$$

Where:

TSM = Total number of personnel assigned to squadron.

BMP = Base services manpower percentage (.17).

C = Cost per man

Manpower Breakdown:

316 x .17[66] = 54 Total base services manpower

Where:

54 x .02 = 2 officer
54 x .73 = 40 airmen
54 x .25 = 13 civilian

8) Miscellaneous Personnel Support: The cost of supplies and equipment needed to support base personnel who directly support ARPV squadron personnel. This includes administrative supply items, expendable equipment and office machines, custodial services and other personnel-oriented support items (desks, chairs, etc.).

$$= (BSM)\ (SC) \div (TSM)\ (SC)\ (BSP)$$

Where:

BSM = Number of personnel assigned to Base services. (41)

SC = Support cost per man. ($790)

TSM = Total number of personnel assigned to squadron.

BSP = Support percentage attributed to Base Services personnel. (.85)

[66] Operating and Support Cost Estimates--Aircraft Systems Cost Development Guide, Defense Systems Acquisitions Review Council, (May 1974), p. 34.

C. Logistics Support: This includes all the maintenance, supply, and other logistics activities necessary to support squadron operations in their accomplishment of the units' mission.

9) On-Equipment Maintenance Cost: The flightline maintenance labor costs to perform corrective maintenance in place or to remove and replace line replaceable units (LRU) for subsequent repair. It also includes the labor costs to perform scheduled maintenance and inspections on the subsystem.

$$= \sum_{h=1}^{SS} \sum_{i=1}^{N} \left[\frac{(TFOH)(QPA_i)(BLR)}{MOTBMA_i}\right] \left[(RIP_i)(IMH_i)+(1-RIP_i)(RMH_i)\right] + \frac{(TFOH)(SMH)(BLR)}{(SMI)}$$

Where:

SS = Number of subsystems evaluated (airframe, avionics, and propulsion) (3)

N = Number of LRUs in the subsystem. **(Average 4/Subsystem)**

TFOH = Expected total force operating hours over the program Inventory Usage period. **(35,240 per year)**

QPA_i = Quantity of the i^{th} LRU contained in the subsystem. (1)

BLR = Average base-level labor rate in dollars/manhour. (9.37/M.H.)

$MOTBMA_i$ = Mean operating time between maintenance actions for the i^{th} LRU in the mature system. (250)

RIP_i = Fraction of operational failures of the i^{th} LRU which can be repaired in place. (.30)

IMH_i = Average manhours to perform corrective maintenance in place for the i^{th} LRU. (1.5)

RMH_i = Average manhours to remove and replace the i^{th} LRU. (1.5)

SMH = Average manhours to perform scheduled maintenance (including preventive maintenance, preflight, post-flight and periodic inspections of the subsystem). (10)

SMI = Scheduled maintenance interval in operating hours for the subsystem. (240)

10) Off-Equipment Maintenance Cost: This equation gives labor and material costs for base and depot maintenance facilities to diagnose, repair or attempt to repair LRUs. Included are the associated packing and shipping costs incurred for the items expected to be returned to depot for repair.

$$= \sum_{h=1}^{SS} \sum_{i=1}^{N_{\cdot}} \frac{(TFOH)(QPA_i)(1-RIP_i)}{MOTBMA_I} \Big\{ RTS_i \Big[(BMC_i)(UC_i) + (BMH_i)(BLR) \Big] + NRTS_i \Big[(DMC_i)(UC_i) + (DMH_i)(DLR) \Big] + \Big[(1-OS)(PSC) + (OS)(PSO) \Big] (1.25\ W_i) \Big[2(NRTS_i) + (COND_i) \Big] \Big\}$$

Where:

TFOH = Expected total force operating hours over the program Inventory Usage period.

QPA_i = Quantity of the i^{th} LRU contained in the subsystem.

RIP_i = Fraction of operational failures of the i^{th} LRU which can be repaired in place.

$MOTBMA_i$ = Mean operating between maintenance actions for the i^{th} LRU in the mature system.

RTS_i = Fraction of removals of the i^{th} LRU expected to be repaired at the base. (.60)

BMC_i = Average material cost per base maintenance action expressed as a fraction of the unit cost (UC) of the i^{th} LRU. The material cost includes the mean dollar value of the consumables utilized in repairing the i^{th} LRU and any subordinate repairables of the LRU. (.20)

UC_i = Expected unit cost of the i^{th} LRU; ie., the cost expected to be exhibited at the time of initial provisioning for the i^{th} LRU. (50,000)

BMH_i = Average manhours at base level to diagnose, repair or attempt to repair the i^{th} LRU. (45.0)

BLR = Average base-level labor rate in dollars/manhour.

$NRTS_i$ = Fraction of removals of the i^{th} LRU expected to be returned to the depot for repair. (.30)

DMC_i = Same as BMC except refers to depot maintenance actions.(.20)

DMH_i = Same as BMH except refers to depot manhours. (40.0)

DLR = Average depot labor rate in dollars/manhours. (12.91)

OS = Fraction of the total force deployed to overseas locations. (.90)

PSC = Average packing and shipping cost in dollars/pound for overseas CONUS locations. ($.35/lb)

PSO = Average packing and shipping cost in dollars/pound for overseas locations. ($.77/lb)

W_i = Weight in pounds of the i^{th} LRU. (10)

$COND_i$ = Fraction of removals of the i^{th} LRU expected to result in condemnation at base level. (.10)

11) Inventory Entry And Supply Management Cost: This equation gives the management cost to introduce new line items into the Air Force inventory as well as recurring supply management costs.

$$= \sum_{h=1}^{SS} \left\{ \left[IAC + (PIUP-1)(RAC) \right] \sum_{i=1}^{N} (PA_i + 1) + \left[IPC + (PIUP-1)(RPC) \right] \sum_{i=1}^{N} (PP_i) + (M)(SA)(PIUP) \left[N + \sum_{i=1}^{N} (PA_i + PP_i + SP_i)^* \right] \right\}$$

NOTE: If $RTS_i = 0$, this last term becomes (M)(SA)(PIUP)

Where:

IAC = Initial inventory management cost to introduce a new "P" coded reparable assembly into the Air Force inventory. ($104.20)

M = **Number of operating base locations**

IPC = Same as IAC except refers to consumable items. (\$104.20/item)

PIUP = Operational service life of the system in years. (15 Yrs)

RAC = Recurring inventory management cost to maintain a reparable assembly in the wholesale system (expressed in dollars/item/year) (\$104.20/item/year)

RPC = Same as RAC except refers to consumable items. (\$104.20/item/year)

PA_i = Number of new "P" coded reparable assemblies within the i^{th} LRU. (1)

PP_i = Number of new "P" coded consumables within the i^{th} LRU. (6)

M = Number of operating base locations. (4)

SA = Annual base supply inventory management cost in dollars/item/year. (\$12/item/year)

SP_i = Number of standard (already stock-listed) parts within the i^{th} LRU. (5)

12) Cost of Management and Technical Data: This equation gives the cost for Technical Orders (T.O.s), overhaul manuals, and other special technical documentation of repair instructions. It also computes the maintenance labor costs to complete on-and-off-equipment maintenance records, supply transaction records and transportation forms.

$$= \sum_{n=1}^{SS} \sum_{i=1}^{N} \frac{(TFOH)(QPA_i)(BLR)}{MOTBMA_i} \left[(MRO) + (1-RIP_i)(MRF + SR + TR \right] + \frac{TFOH}{SMI} (BLR) \left[MRO + (0.1)SR + (0.1)TR \right] + TD\,(JJ + H)$$

Where:

MRO = Average manhours per maintenance action to complete on-equipment maintenance records. (.08 hours)

MRF = Average manhours per maintenance action to complete off-equipment maintenance records. (.24 hours)

SR = Average manhours per maintenance action to complete supply transaction records. (.25 Hours)

TR = Average manhours per maintenance action to complete transportation forms. (.16 Hours)

TD = Cost per original page of technical documentation. ($160 Per Page)

JJ = Number of pages of organizational and intermediate level T.O.s. (740)

H = Number of pages of depot level T.O.s and special repair instructions. (975)

13) <u>Cost of Spare Engines</u>: This equation gives the cost of whole spare engines required in the base and depot pipeline to support the weapon system.

$$= (EUC) \left[(LS)(X) + \frac{(EPA)(ENRTS)(DP + D)(PFFH)}{CMRI} \right]$$

Where:

EUC = Expected engine unit cost. ($144,300) J85/J1A-General Electric

LS = Number of stockage locations for spare engines. (2)

X = Number of whole spare engines to stock at each location. (5)

EPA = Number of engines per aircraft. (1)

ENTRS = Engines not reparable this station; percentage of engines expected to be repaired at the depot. (.5)

DP = Engine repair cycle time in months at the depot. (.73)

D = Number of months worth of depot safety stock for the engine. (.5)

CMRI = Mean engine operating hours between removal.(1000 flying hours)

PFFH = Expected peak force flying hours per month. (16.7)

D. Personnel Support: This includes the acquisition and training of replacement personnel, medical support, and PCS costs in support of the squadron.

14) Recruit/Technical Training Manpower: The cost of paying personnel in training who will replace non crew personnel.

$$= \sum_{i=1}^{3} (TSM_i + BSM_i)(ATR)(C_i), \ i = 1 \text{ (Off)}, 2 \text{ (air)}, 3 \text{ (Civ)}$$

Where:

ATR = Annual Turnover Rate (.15) [67]

15) ARPV Crew Training Cost: The cost of paying personnel in training who will replace unit ARPV crews and the cost of their instruction.

$$= (RPVC)(CTR)(CPC) + (RPVT)(TTR)(CPT)$$

Where:

RPVC = Number of squadron ARPV crew controllers. (30)

CTR = Annual controller Turnover Rate. (.094)

CPC = Cost per crew controller. ($12,637)

RPVT = Number of squadron ARPV crew technicians. (30)

TTR = Annual Technician Turnover Rate (.134)

CPT = Cost per crew technician. ($7400)

16) Medical Manpower: The cost of paying medical personnel needed to provide direct support to the ARPV squadron; and training pipeline personnel.

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[67] Ibid, p. 38.

$$= \sum_{i=1}^{3} (TSM_i + BSM_i + PSM_i)(MMSR)(C_i),\ i = 1\ (Off),$$
$$2\ (Air),\ 3\ (Civ)$$

Where:

PSM= Total number of personnel in training status. (54)

MMSR = The number of medical personnel per military person (Medical Manpower Support Rate) (.016)

Medical Manpower Breakdown:[68]

411 x .016 = 7 Medical Personnel

Where:
7 x .21 = 2 Officers
7 x .62 = 4 Airmen
7 x .17 = 1 Civilian

17) Medical Material: The cost of materiel required to support ARPV squadron personnel; base personnel who provide direct support to the ARPV squadron, and training pipeline personnel.

$$= (TSM + BSM + PSM)(MSCM)$$

Where:
MSCM = Materiel Support Cost Per Man ($157)

18) Permanent Change of Station (PCS): The costs incident to the PCS of: ARPV unit military either individually or as organized units; base personnel who provide direct support to the ARPV unit; and training pipeline personnel.

$$= \sum_{i=1}^{2} (TSM_i + BSM_i + PSM_i)(PCS_i),\ i = 1\ (Off),\ 2\ (Air)$$

[68] Ibid.

Where:

PCS = Permanent Change of Station cost per man. (Officer; \$3419, Airman; \$2028)

19) <u>Miscellaneous Personnel Support</u>: The cost of expendable supplies and equipment needed by instructor, trainee and medical personnel who support ARPV squadron personnel.

$$= (PSM)(PSC)$$

Where:

PSC = Personnel support cost per man. (\$760)

Recurring Investment: This includes costs for initial spares, recurring modifications to equipment, support equipment (AGE), and training missile and munitions.

20) <u>Initial and Replacement LRU Spares Cost</u>: This equation gives the initial investment cost of LRU spares necessary to support the repair pipelines and the purchase cost of spares to replace condemned LRUs. The computation includes a spares safety level quantity to provide protection against fluctuation in item demands. This quantity is determined based on an expected backorder criterion.

$$= \sum_{n=1}^{SS} \sum_{i=1}^{N} (STK_i)(UC_i)(M) + \sum_{i=1}^{N} \frac{(PFOH)(QPA_i)(1-RIP_i)(UC_i)}{MOTBMA_i} \left[(DRCT_i)(NRTS_i)\right] + \sum_{i=1}^{N} \frac{(TFOH)(QPA_i)(1-RIP_i)(UC_i)}{MOTBMS_i} (COND_i)$$

Where:

STK_i = Base stock level for the i^{th} LRU which includes a safety stock level. (1.0)[69]

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[69] <u>Logistics Support Cost Model User's Handbook</u>, January 1976.

UC_i = Expected unit cost of the i^{th} LRU: it., the cost expected at the time of initial provisioning for the i^{th} LRU.

$DRCT_i$= Average depot repair cycle time in months for the i^{th} LRU. (2.25)

21) Recurring Modifications (Class IV): The cost of modifying ARPVs ground equipment, and training equipment that are in the operating inventory to make them safe for continued operations, to enable them to perform mission essential tasks (not new capability), and to improve reliability or reduce maintenance cost.

$$= (UE)(AFC)(RMP)$$

Where:

AFC = Average flyaway cost of buying a new ARPV. ($600,000)

RMP = Recurring Modification Percentage. (.0038)

22) Cost of Support Equipment (ACE): This equation computes the cost of peculiar support equipment based on the anticipated workload and servicing capability. The cost of additional units of common support equipment is also included.

$$= \sum_{h=1}^{SS} \sum_{i=1}^{N} \frac{(PFOH)(QPA_i)(1-RIP_i)}{MOTBMA_i} \sum_{j=1}^{K} \left\{ \frac{(RTS_i)(BMH_i)}{(BUR_j)(1-DOWN_j)(BAA)} \left[(CAB_j) + (PIUP)(COB_j) \right] + \frac{(NRTS_i)(DMH_i)}{(DUR_j)(1-DOWN_j)(DAA)} \left[(CAD_j + (PIUP)(COD_j) \right] \right\} + FLA + BA + DA + CS + IH$$

Where:

BUR_j = Base-level utilization rate for AGE end item i; $0 < BUR_j \leq 1$. (.70)

DUR_i = Depot utilization rate for AGE end item i; $0 < DUR_i \leq 1$. (.90)

BAA = Total active work time in the base shop per month. (200)

DAA = Total active work time in the depot per month. (32)

CAB_i = Cost per unit of peculiar base AGE end item i. ($50,000)

CAD_i = Same as CAB_i except relates to depot AGE. ($50,000)

COB_i = Cost per year per unit of operating peculiar base AGE end item i. ($25,000)

COD_i = Same as COB_i except relates to depot AGE. ($25,000)

$DOWN_i$ = Fraction of downtime for AGE end item i for calibration requirements; $0 \leq DOWN_i < 1$. (.05)

K = Number of line items of peculiar AGE used in repair of the i^{th} LRU. (3)

FLA = Cost of additional common or peculiar flight-line AGE to support the subsystem ($91,000)

DA = Apportioned cost of additional common depot support equipment. ($1,250,000)

BA = Apportioned cost of additional common base shop support equipment. ($685,000)

CS = Cost of software to utilize existing automatic test equipment. ($82,000)

IH = Cost of interconnecting hardware to utilize existing automatic test equipment. ($38,400)

23) <u>Training Munitions</u>: The cost of munitions expended by the squadron for the purpose of keeping ARPV crews proficient in weapons delivery techniques.

$$= (AC)(MCR)$$

Where:

AC = Number of ARPV crews. (15)

MCR = The munitions cost estimate per ARPV crew per year. ($15,000)

24) <u>Training Missiles</u>: The cost of missiles expended by the squadron for the purpose of keeping ARPV crews proficient in weapons delivery techniques.

= (AC)(MSC)

Where:

MSC = The cost estimate for missile firings used to train ARPV crews. (42500)

Examination of Selected Variables

The purpose of this section is to examine the list of cost variables that are significant cost drivers and develop trade-off curves for those variables that have the most significant impact on total O & S costs over a 15 year period for the Advanced RPV Squadron. First, the variables in the 24 cost element equations were examined for their frequency in the equations, their comparative values and potential impact on the total O & S cost. This preliminary screening served to scope the number of variables that should be more closely analyzed. The result was a list of 41 cost variables. Next, each of the cost variables was evaluated by changing their values over a range from -50% to +50% and salculating a new total cost for the O & S model. The respective percentage change in total O & S costs was calculated and analyzed for its significance. Finally, those cost variables that had the most significant changes to total O & S costs were further investigated by developing trade-off curves for each. This was done by plotting the percentage change in the cost variable versus the resulting percentage change in total O & S costs. The points on the trade-off curves represented percent changes of -50%, -25%, 0%, +25%, and +50% of the cost variable. This curve was then analyzed for its significance and value to the user of the O & S Cost Model. The judgement of this writer is that these cost variables are the ones that the ARPV program manager should pay careful attention to in order to prevent O & S costs, and ultimately life cycle costs, from exceeding planned goals.

Caution must be taken when interpreting the numerical estimates of the variables used by this writer in the model. Most of the estimates were taken from historical data on other hardware systems, but some of the estimates were this writer's best judgement. Also, the purpose in presenting

cost estimates was to exercise the model and demonstrate its usefullness as a management tool in identifying cost drivers for a specific weapon system design. For this purpose, the estimates were judged to be sufficiently valid to establish a cost baseline and show variances from it caused by certain cost variables. It is not the magnitude of the estimates, but the relative differences or changes that is the important product of this cost model. It should also be understood that many, if not most, of these estimates will change as the design of the ARPV squadron evolves through the conceptual studies and the validation phase. This model should provide a tool for comparing O & S costs for various system designs.

In Table VII are listed the 41 cost variables that were evaluated over a range of -50% to +50%. Several of the most significant were chosen to demonstrate their sensitivity to total O & S costs by developing trade-off curves for each.

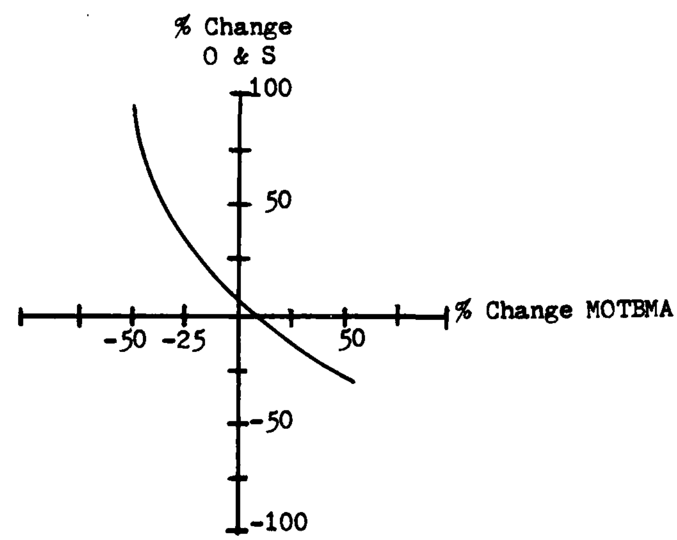
TABLE VII

COST VARIABLES VS TOTAL O & S COSTS

	Variable	-50%	-25%	0	+25%	+50%
1)	MOTBMA	+87	+28	0	-17	-28
2)	TSM	- 2.41	- 1.22	0	+ 1.22	+ 2.42
3)	TFOH	-48	-27	0	+38	+46
4)	QPA	-33	-15.6	0	+15.6	+33
5)	RIP	+21	+10	0	-11	-21
6)	NRTS	-20.4	-10.2	0	+10.2	+20.4
7)	UC	-19.6	- 9.8	0	+ 9.8	+19.6
8)	RTS	-18	- 9	0	+ 9	+18
9)	BMC	-13.1	- 6.5	0	+ 6.5	+13.1
10)	DMH	- 8.8	- 4.4	0	+ 4.4	+ 8.8
11)	COD	- 8.1	- 4.1	0	+ 4.1	+ 8.1
12)	PFOH	- 7.3	- 3.6	0	+ 3.6	+ 7.3
13)	PIUP	- 7.2	- 3.6	0	+ 3.6	+ 7.2
14)	CAD	- 7.0	- 3.5	0	+ 3.5	+ 7.0
15)	DMC	- 6.6	- 3.3	0	+ 3.3	+ 6.6
16)	DUR	+ 5.6	+28	0	- 2.8	+ 5.6
17)	BMH	- 4.5	- 2.2	0	+ 2.2	+ 4.5
18)	COB	- 3.7	- 1.8	0	+ 1.8	+ 3.7
19)	CAB	- 3.5	- 1.7	0	+ 1.7	+ 3.3
20)	STK	- 3.2	- 1.6	0	+ 1.6	+ 3.2
21)	M	- 3.2	- 1.6	0	+ 1.6	+ 3.2
22)	BUR	+ 2.8	+ 1.4	0	- 1.4	- 2.8
23)	LS	- 2.6	- 1.3	0	+ 1.3	+ 2.6
24)	DRCT	- 2.0	- 1.0	0	+ 1.0	+ 2.0

	Variable	-50%	-25%	0	+25%	+50%
25)	PCS	- 1.6	- .08	0	+ .08	+ 1.6
26)	ATR	- 1.0	.00	0	.00	+ 1.0
27)	DOWN	+ .4	+ .2	0	- .2	- .4
28)	RMP	- .2	- .1	0	+ .1	+ .2
29)	TFFH	.00	.00	0	.00	.00
30)	FC	.00	.00	0	.00	.00
31)	IMH	.00	.00	0	.00	.00
32)	RMH	.00	.00	0	.00	.00
33)	SMI	.00	.00	0	.00	.00
34)	ENRTS	.00	.00	0	.00	.00
35)	DP	.00	.00	0	.00	.00
36)	D	.00	.00	0	.00	.00
37)	CMRI	.00	.00	0	.00	.00
38)	PFFH	.00	.00	0	.00	.00
39)	CTR	.00	.00	0	.00	.00
40)	TTR	.00	.00	0	.00	.00
41)	PSC	.00	.00	0	.00	.00

A. Mean Operating Time Between Maintenance Action (MOTBMA): This variable included the time the equipment is operating on ground alert and the time flying. This combined value should be a weighted average considering the added stress on subsystems when flying compared to the less strenous influence on ground alert. The derivation of such a factor was beyond the scope of this thesis.

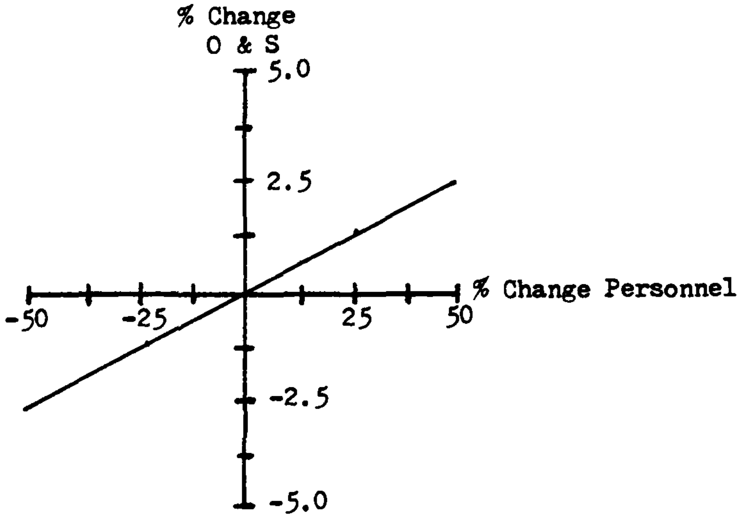


% Change in MOTBMA	% Change in O & S
-50	+87
-25	+28
0	0
+25	-17
+50	-28

Figure 15. MOTBMA

This variable has a significant influence on the total cost for operating and support. This variable should be studied by the program manager and efforts made to improve or increase its value. This would necessitate further study into the relationship between flying activity and ground alert activity.

B. Total Squadron Personnel (TSM): This variable includes all the military personnel assigned to the Advanced RPV squadron. In addition, it determines the number of Base Operating Support Manpower (BSM) and the number of Personnel Support Manpower (PSM). This last group is the number of personnel undergoing training prior to job assignment in the squadron.

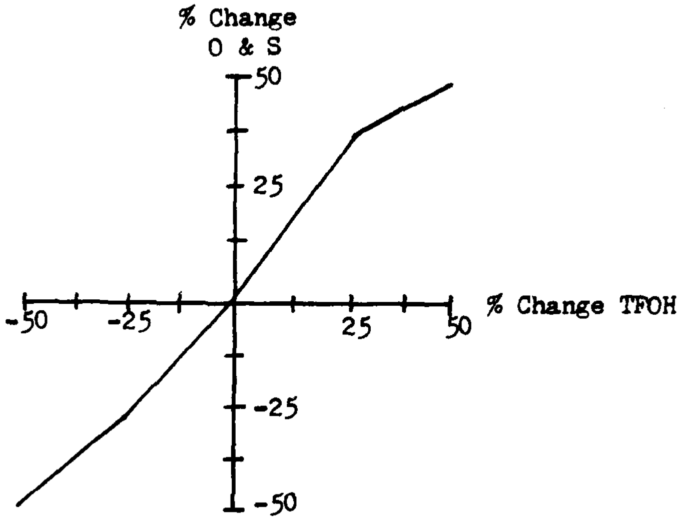


% Change in Personnel	% Change O & S Costs
-50	-2.41
-25	-1.22
0	0
+25	+1.22
+50	+2.42

Figure 16. Total Squadron Personnel

The variable TSM showed a linear relationship with respect to total O & S costs. The influence on total O & S costs was less than was expected. This writer believes this result was due to the selection of a squadron concept that minimized the operational personnel requirements. Additional comments will be made about this subject later in the chapter.

C. Total Force Operating Hours (TFOH): This variable includes the expected total force operating hours over the program inventory usage period. Both the total flying and total ground alert are represented by this variable.

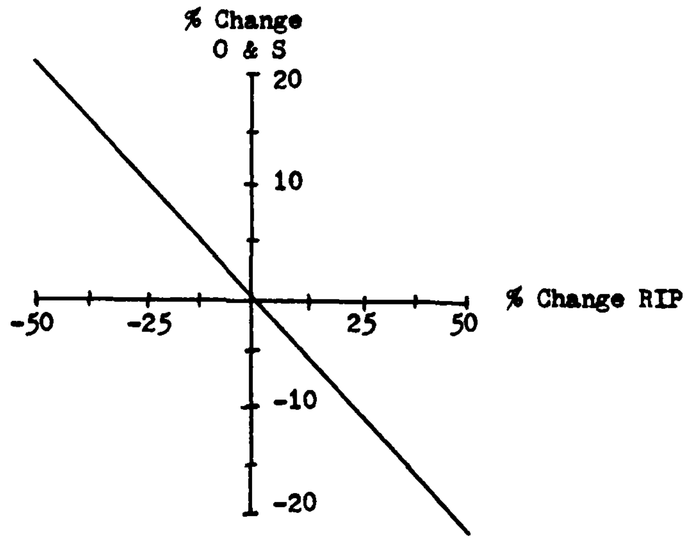


% Change in TFOH	% Change in O & S
-50	-48
-25	-27
0	0
+25	+38
+50	+46

Figure 17. TFOH

This variable is a significant cost driver for O & S costs. The portion attributed to flying can greatly impact the total O & S costs. Thus, this variable should be analyzed for potential cost reductions if it is feasible from a requirements perspective. Also, the impact of fuel cost increases will be significant on this variable.

D. Repaired in Place (RIP): This variable includes the fraction of operational failures of LRUs which can be repaired in place. It has a significant impact on off-equipment maintenance, initial and replacement LRU spares, and support equipment (AGE) costs.



% Change RIP	% Change in O & S
-50	+21%
-25	+10%
0	0
+25	-11%
+50	-21%

Figure 18. Failures Repaired in Place (RIP)

This variable demonstrates that by increasing the capability to repair operational failures in place, significant savings in O & S costs can be realized. This variable is impacted to a large degree by the maintenance concept that is being developed and should be monitored by the program manager. Further research into this variable could be very beneficial.

Significance of O & S Model and Cost Variables

The significance of this O & S cost model for the Advanced RPV squadron is that it provides a tool in which the ARPV program manager can examine different operations and maintenance concepts. This can be done by varying the estimated cost variables or by adding or deleting cost elements as necessary. The model can be used to track cost elements that are significantly high cost drivers. These cost elements can be analyzed and changed if they demonstrate potential O & S cost savings. It is assumed in this thesis that the ultimate goal is to reduce life cycle cost of the ARPV squadron. Thus, O & S costs would not be reduced if they resulted in increased life cycle cost.

The significance of the cost variables is to aid in exercising the O & S model in order to find the most cost effective approach to operating and supporting a squadron of ARPVs. The cost variables are the components that make up the cost element equations, which in turn, define categories of cost (e.g. ARPV Crew Manpower) that are summed up to arrive at total O & S costs. In many cases, a cost variable appears in several cost element equations. When a sensitivity analysis is made on one variable it can impact several cost element equations or categories of cost. The results of this analysis can be important to the program manager as he develops the squadron operations maintenance concepts.

Summary

In chapter V, an O & S cost model for the ARPV squadron was presented. Then, several cost variables from the cost element equations were examined to demonstrate the ability of the model to provide visibility of the high cost drivers. Then, the significance of the O & S cost model and cost variables was discussed. In the next chapter, the summary, conclusions, and recommendations of this thesis will be presented.

CHAPTER VI

SUMMARY

Summary

The purpose of this thesis was to study and analyze the operating and support (O & S) costs of an Advanced RPV squadron. This study concentrated on the determination of costs for operations and support while the weapon system was still in its conceptual phase of acquisition. It was the belief expressed by this writer that early decisions made by the system program manager, with respect to design parameters for a weapon system, can have a major impact on the costs for operating and supporting that weapon system.

A cost model was formulated, to be used by the ARPV program manager that provided operating and support cost visibility. Its purpose was as a tool to provide insight into what cost elements were the high cost drivers. Also, it was intended to be useful in applying different operating and support concepts in order to arrive at the most cost effective squadron concept. For this purpose, a squadron operations and maintenance concept was developed to demonstrate the utility of the model. Finally, several cost variables were examined to show what their impact was on total O & S costs as they were changed over a range of values.

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Conclusions

The objective of presenting an operating and support cost model for the Advanced RPV that could be used to investigate cost variables that have significant impact on total O & S costs has been accomplished. This writer studied O & S costs of various weapon systems and analyzed cost elements of existing operating and support cost models in preparation of formulating an ARPV O & S cost model.

The objective of developing an Advanced RPV squadron concept was satisfied in order to demonstrate the capability of the O & S cost model. The squadron concept outlined the command structure, basing, personnel and training requirements, maintenance concept, operations concept, ARPV description, and mission profiles. The squadron concept provided the baseline in which to develop cost estimates for the variables used in the cost model. The accomplishment of this objective provided insight and visibility into the problems confronting Air Force Weapon Systems designers in controlling operating and support costs.

The investigation of certain cost variables that are uniquely found and/or significantly changed in an ARPV squadron was satisfactorily accomplished. It was determined that the **failures repaired in place** (RIP) **variable** identified **was** significant enough that the ARPV program manager should continue to study and analyze them.

The reliability variable, Mean Operating Time Between Maintenance Action (MOTBMA), was determined to need additional study and analysis to consider all the ramifications. The potential use of a combined weighted factor for the MOTBMA was suggested.

In conclusion, this thesis should provide the capability for program office personnel to conduct operating and support cost analyses. In addition, it should help to identify those high cost elements that significantly impact operating and support cost and ultimately life cycle costs.

Even though the thesis work was done in 1975, it is the judgement of this writer that the work presented here is sufficiently valid in 1980. It is also felt that it can contribute to the development and analysis of O & S cost of future DOD weapon systems.

BIBLIOGRAPHY

Reports and Studies

1. AFSC/AFLC. Life Cycle Cost (LCC) Study. Washington D.C.: Air Force Systems Command, September 1972.

2. Air Combat Fighter Life Cycle Cost Impacts and Tradeoffs. Air Combat Fighter SPO, ASD/YP, 17 January 1975.

3. Aircraft Depot Maintenance Cost Factors. AFLC/MCCC, WPAFB, Ohio.

4. Adams, Donald F. Airframe Structural Materials for Drone Applications. RAND Corp. R-581/4-ARPA, July 1971.

5. Advanced RPV Conceptual Phase Proposal, Teledyne Ryan Aeoronautical, February 1975.

6. Analysis of Available Life Cycle Cost Models and Actions Required to Increase Future Model Applications. Joint AFSC/AFLC Life Cycle Cost Working Group. ASD/ACL, December 1974.

7. Batchelder, C.A., H.E. Bren, Jr., H.G. Campbell, J.A. Dei Rossi, and J.P. Large. An Introduction to Equipment Cost Estimating. RAND Corp. RM-6103-SA, December 1969.

8. Boden, William H. Designing for Life Cycle Cost. Ft. Wayne, Indiana: The Magnavox Company, 1 September 1974.

9. Boren, H. E., Jr. DAPCA: A Computer Program For Determining Aircraft Development and Production Costs. RAND Corp., Santa Monica, Ca., RM 5221 PR, February 1967.

10. Boren, H. E., Jr. Modifications To Individual Weapon System Computer Cost Model. RAND Corp., Santa Monica, Ca., RM-4165-PR, December 1968.

11. Bradley, B. D. An Approach to Operating and Support Cost Estimates for Review by the DSARC RAND. Santa Monica, Ca., WN-8680-PAE, May 1974.

12. Campbell, H. G. Aerospace Price Indexes. RAND Corp., R-568-PR, December 1970.

13. Catalog of Logistics Models. Department of Defense. U. S. Army Logistics Management Center, 1975.

14. Cavender, R. E. Application of the A-X 10 Year Operating and Support Cost Model to the F-4E. O. A. Office, Hq AFLC, WPAFB, Ohio, O. A. Tech Memo No. 14, March 1971.

15. Conceptual Phase Proposal for the Advanced RPV. Northrop Corp., Ventura Division, February 1975.

16. Cost-A Principal System Design Parameter, Symposium Proceedings. AFMA/NSIA Washington, D. C. 16-17 August 1972.

17. Cost Estimating Relationships. Vaughn, et al, LR 23130, December 1969.

18. Depot Maintenance-Cost Estimating Relationships for Fighter Aircraft. DCS/Comptroller, Hq AFLC, WPAFB, Ohio, MCCC-70-001, March 1970.

19. Depot Maintenance Costs for Selected Air Force Missiles. AFLC/MCCC, WPAFB, Ohio, no date.

20. Description of the "Support to Cost/Effectiveness Analysis for Reliability Programs" Model (SCARP), draft paper.

21. Determination of the Cost to Retain Selected Aircraft Weapon Systems. AFLC: AFLC AD HOC Group, September 1972.

22. Economic Analysis and Program Evaluation for Resource Management, Department of Defense Instruction 7041.3, 18 October 1972.

23. Fiorella, Marco. Data Issues Related to Life Cycle Costing During Weapon System Acquisitions. Santa Monica, California: RAND. WN-8679-PAE, May 1974.

24. Fiorella, M. R. Data Systems for Life Cycle Cost Information: Some Issues and Recommendations. Santa Monica, California: RAND. WN-8238-ARPA, May 1973.

25. Gibson, John D. S. Supplemental Life Cycle Costing Program Management Guidance. Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, March 1975.

26. Gideon, Francis C., Lt Gen. The Air Force Logistics Command Looks at Systems Acquisition. Ft. Belvoir, Va., 1 September 1971.

27. Goldman, A. A. Problems in Support Cost Estimation Affecting System Design and Procurement Selection. Santa Barbara, California: General Electric Company (TEMPO).

28. Green, Terrell E. Some Design Possibilities for Tactical Aircraft in the Decade Ahead. RAND Corp. April 1970.

29. Gross, Alan J. and William W. Hogan, Jr. Aircrew Ratio Studies. RAND Corp. RM-5843-PR, December 1968.

30. Hansen, Bertrand L. Quality Control-Theory and Applications. Prentice-Hall Inc. Englewood Cliffs, N. J., 1963.

31. Hughes Cost of Ownership Model (HCOM). Prepared for Naval Weapons Center, February 1973.

32. Implementation of the Life Cycle Costing Acquisition Technique-Department of Defense. Washington D. C.: Comptroller General of the U. S., GP-22, November 1972.

33. Jacobson, R. H., Lt Col, USAF, Low Cost Tactical RPVs, RAND Corp., September 1972.

34. Johnson, W. L. and R. E. Reel. Maintainability/Reliability Impact on System Support Costs. Seattle, Washington: Boeing Aerospace Company, AFFDL-TR-73-152, December 1973.

35. Kaplan, Richard J., John Y. Lee, and Robert M. Paulson. SCAM-A System Support Cost Analysis Model. RAND Corporation, Santa Monica, Ca., RM-6049-PR, November 1969.

36. Katz, Irving. Challenges in the Reliability and Maintainability Aspects of Logistics. Hq AFLC, WPAFB, Ohio 25th MORS, 17 June 1970.

37. Katz, Irving. Cost-Effectiveness in System Acquisition -- A logisticians Perspective. Hq AFLC, WPAFB, Ohio, paper to ASQC, 19 May 1971.

38. Katz, Irving. Aspects of Accuracy in Reliability and Maintainability. Hq AFLC, 28-29 October 1971.

39. LaBelle, J. P. and D. N. Burt. Integrated Logistics Support Planning During the Conceptual Phase of the Air Force System Acquisition Process-The Interrelationship between the Logistician and the Feasibility Study Contractor. AFIT, WPAFB, Ohio, School of Systems & Logistics, no date.

40. LCC Reference Notebook. Life Cycle Cost Working Group, WPAFB, Ohio, 18 May 1973.

41. LCC-1 Life Cycle Costing Procurement Guide (Interim). DoD, Washington, D. C., July 1970.

42. LCC-2 Casebook-Life Cycle Costing in Equipment Procurement. DoD, Washington, D. C., July 1970..

43. LCC-3 Life Cycle Costing for System Acquisition (Interim). DoD, Washington, D. C., 13 September 1972.

44. Lewis, Donald E. and Thomas T. Tierney. Meeting Tommorrow's Logistics Challenges. RAND P-686-PR, March 1971.

45. Life Cycle Cost Estimating-Its Status and Potential Use In Major Weapon System Acquisitions. Comptroller General of the United States, 30 Dec 1974.

46. Life Cycle Cost Meeting/Workshop-Summary of Proceedings. AFSC/AFLC Commanders' Working Group on Life Cycle Cost, 21-23 January 1975.

47. Life Cycle Cost Methods Workshop-Summary of Proceedings. Joint AFSC/AFLC Working Group on Life Cycle Cost, WPAFB, Ohio, 31 October - 1 November 1973.

48. Life Cycle Costing-A Better Way to Buy. U. S. Air Force (AF/LFPLA) February 1974.

49. Logistic Support Analysis (2 parts). DoD, Washington, D. C. MIL-STD-1388-1, 31 August 1972.

50. Logistics Support Cost (LSC) Model User's Handbook. Hq AFLC, WPAFB, Ohio, January, 1975.

51. Losee, John E. Logistics Development During the Conceptual and Contract Definition Phases for USAF Programs. Douglas Aircraft Company, Inc., Presented at 1967 SAE/AIAA/AFME R&M Conference, 17-19 July 1967.

52. Paulson, R. B., et al. Using Logistics Models in System Design and Early Support Planning. Santa Monica, California: The RAND Corporation, R-550-PR, February 1971.

53. Pieruschka, Erich. Principles of Reliability. Prentice-Hall Inc., Englewood Cliffs, N.J.

54. Review of the Application of Life Cycle Costing to the A-X/A-10 Program (1970-1973), Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, WPAFB, Ohio.

55. Shooman, Martin R. Probalistic Reliability: An Engineering Approach. McGraw-Hill Book Co., 1968.

56. Smith, C. C. Cost Effectiveness Methodology - 3 Volumes, New York: TRW Systems Group for RADC Griffis AFB, RADC-TR-68-119, July 1968.

57. Summary of Proceedings-Life Cycle Cost Meeting/Workshop. Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, 21-23 January 1975.

58. Swafford, F., Major, Operating and Support Cost Comparison A-7 versus A-10. DoD/ODDPA&E, 2 May 1973.

59. Tenzer, A. J. Cost Sensitivity Analysis. RAND Corp., March 1965.

60. Timson, F. S. Practicality of Life Cycle Cost Models As Aids to Acquisition Decision making: Confidence in Estimates. Santa Monica, California: The RAND Corporation, WN-8237-ARPA, May 1973.

61. Weapons Guidance Laboratory Reliability Conference. ARINC Research Corporation, Nov 15 - Dec 15, 1960, Publication No. 123-7-196.

62. Weapon System Ownership Cost Modeling Phase I. (Task 75-1) Logistics Management Institute, October 1974.

63. Weifenback, Annette. Base Maintenance Activity and Repair Cycle Times. RAND Corp., RM 5027 PR, September 1966.

64. Young and Feist. A Study of the Application of Integrated Logistics Support in the Conceptual Phase of Weapon System Acquisition. AFIT, WPAFB, Ohio, SISR-25-70 (thesis), 19 August 1970.

APPENDIX A

MISSILE ANNUAL COST ESTIMATING (MACE) MODEL

I. Recurring Investment and Miscellaneous Logistics

Peculiar Age: Aerospace ground equipment for a specific weapon system.

Maintenance-missile: Base level maintenance on missile and missile support equipment (material only).

Depot Maintenance: Depot maintenance on missile and missile support equipment.

Modification, Class IV (inc. Initial Spares): Provided for updating modifications of missile weapon systems and drones, direct ground support equipment, and training equipment (missile).

Replenishment Spares: High cost reparable items that are repaired when damaged so long as the estimated cost of repair is 65% or less of the acquisition cost. If these conditions are not met, the items are condemned at either base or depot level.

Operational Missile Test and Analysis: Selected missile firing and analysis of results. For example, missiles transported to Vandenburg AFB, California and refitted with test equipment.

Vehicular Equipment: Operation and Maintenance of Vehicles listed of commercial design and general-purpose use.

II. Pay and Allowance (P & A)

Military: Pay and allowance for military personnel.

Civilian: Pay and allowance for civilian employees.

Source: USAF Cost and Planning Factors (U), Cost Analysis, AFR 173-10, Volume 1, (6 February 1975).

III. Base Operating Support/Real Property Maintenance (BOS/RPM), Support of

Primary Program Element (PPE) Manpower: Allocation of base operating support costs to primary program element (squadron manpower).

BOS/RPM manpower: The share of base operating support costs attributed to personnel employed in the categories of Base Operating Support and Real property maintenance.

IV. Medical, Support of

Officers: Allocation of medical dispensary costs to officers.

Airmen: Allocation of medical dispensary costs to airmen.

V. Personnel Support

PCS-Officers: Cost of travel for officers and dependents and associated costs such as transportation of personal property, dislocation allowance, and so forth.

PCS-Airmen: Cost of travel for airmen and dependents and associated costs such as transportation of personal property, dislocation allowance, and so forth.

VI. Pipeline Costs

Acquisition-Officers: Estimate of the cost of acquiring an officer from the principle sources currently used by the Air Force.

Acquisition-Airmen: Estimate of the cost of acquiring an airman from the principle sources currently used by the Air Force.

Training-Officers: Estimate of cost for attaining Air Force specialty classification for officers.

Training-Airmen: Estimate of cost for attaining Air Force specialty classification for airmen.

APPENDIX B

COST ANALYSIS IMPROVEMENT GROUP (CAIG) MODEL

I. Squadron Operations

Combat Command Staff Manpower: The cost of paying the personnel required for flying supervision. These personnel perform such jobs as command, operations control, planning and scheduling, flying safety, quality control on aircrew training and flying proficiency and include the combat commander, his staff and the squadron commanders and their respective staff.

Aircrew Manpower: The cost of paying the full complement of crews required to man unit aircraft. This includes all of the crews necessary for the efficient operation of the unit in meeting combat readiness requirements; training requirements; and administrative requirements such as leave, sickness, TDY, etc.

Base Aircraft Maintenance Manpower: The cost of paying the personnel needed to meet base level maintenance requirements of the operational squadron. This includes manpower needed to meet the direct maintenance demands of the assigned aircraft and ground equipment, to provide for maintenance supervision and to cover administrative requirements such as leave, sickness, TDY, etc.

Base Munitions Maintenance Manpower: The cost of paying personnel needed for: loading, unloading, arming and dearming of squadron munitions; inspection, testing and maintenance of all aircraft weapons release systems; maintenance, ammunition loading, activation and deactivation of aircraft gun systems; and maintenance and handling of the munitions stockpile authorized.

Source: Operating and Support Cost Estimates--Aircraft Systems Cost Development Guide, Defense Systems Acquisitions Review Council, (May 1974).

Aircraft Security Manpower: The cost of paying personnel needed for aircraft equipment security: For example, entry control, close and distant boundary support, and security alert teams.

Aviation POL: The cost of buying Petroleum, Oil and Lubricants (including fuel additives) used by the squadron aircraft.

Base Aircraft Maintenance Material: The cost of purchasing materiel from the General and System Support Divisions of the Stock Fund. This includes all non-reparable expense type items including aircraft, electronic and communication repair parts, and base operating consumables used in the organizational, periodic, or field maintenance activities at base level.

Miscellaneous Personnel Support: The cost of supplies, services and equipment needed to support aircraft unit personnel. This includes administrative supply items, expendable equipment and office machines, custodial services and other personnel-oriented support items (desks, chairs, etc.).

II. Base Operating Support

Base Services Manpower: The cost of paying those base personnel necessary to directly support squadron personnel include activities such as food service, supply, motor pool and payroll operations. The sum of these costs represent the pay of those base people who would leave the base if the operating requirement were to move elsewhere.

Miscellaneous Personnel Support: The cost of supplies and equipment needed to support base personnel who directly support aircraft unit personnel. This includes administrative supply items, expendable equipment and office machine, custodial services and other personnel-oriented support items (desks, chairs, etc.).

III. Logistics Support

Depot Maintenance Manpower and Materiel: The cost of materiel and the pay of people required to perform major overhaul of aircraft including complete rebuilding and manufacture of parts. This maintenance involves greater technical capability and more extensive facilities than are available at base level.

Supply Depot Manpower and Materiel: The cost of materiel and salaries of depot and base personnel needed to perform the distribution of aircraft supplies and parts to and from supply depots to points of use or repair.

Second Destination Transportation: The cost of shipping supplies and materiel needed to support aircraft unit equipment and personnel. These costs include shipment of spare and repair parts to and from the repair depots.

IV. Personnel Support

Recruit/Technical Training Manpower: The cost of paying personnel in training who will replace unit personnel.

Undergraduate Pilot/Navigator Training: The cost of paying personnel in training who will replace unit aircrews and the cost of their instruction including the pay of instructor personnel.'

Medical Manpower: The cost of paying medical personnel needed to provide direct support to the aircraft unit; and training pipeline personnel.

Medical Materiel: The cost of materiel required to support aircraft unit personnel; base personnel who provide direct support to the aircraft units, and training pipeline personnel.

Permanent Change of Station (PCS): The costs incident to the PCS of: aircraft unit military personnel either individually or as organized units; base personnel who provide direct support to the aircraft unit; and training pipeline personnel.

Miscellaneous Personnel Support: The cost of expendable supplies and equipment needed by instructor, trainee and medical personnel who support aircraft unit personnel.

V. Recurring Investment

Replenishment Spares: The cost of procuring aircraft assemblies, spares and repair parts which are normally repaired and returned to stock. In addition, it includes procurement of stock levels that are not provided by initial spares procurement. These are centrally managed investment type items. War Readiness Materiel is excluded.

Recurring (Class IV) Modifications: The cost of modifying aircraft, ground equipment, and training equipment that are in the operating inventory to make them safe for continued operation, to enable them to perform mission essential tasks (not new capability), and to improve reliability or reduce maintenance cost. Includes spares.

Common Aircraft Ground Equipment: The cost of procuring common ground servicing equipment, maintenance and repair shop equipment, instruments and laboratory test equipment, and other miscellaneous items including spares for this equipment. Covers such items as ground generators, jet engine test stands, test sets for radios, radars and fire control systems, hand tools, compressors, gages and other minor items.

Training Munitions: The cost of munitions expended by the Unit for the purpose of keeping aircrews proficient in weapons delivery techniques.

Training Missiles: The cost of missiles expended by the Unit for the purpose of keeping aircrews proficient in weapons delivery techniques.

APPENDIX C

LOGISTICS SUPPORT COST (LSC) MODEL

Initial and Replacement Line Replaceable Units Spares Cost. This equation gives the initial investment cost of LRU spares necessary to support the repair pipelines and the purchase cost of spares to replace condemned LRUs. The computation includes a spares safety level quantity to provide protection against fluctuation in item demands. This quantity is determined based on an expected backorder criterion.

On-Equipment Maintenance Cost. This equation gives the flightline maintenance labor costs to perform corrective maintenance in place or to remove and replace LRUs for subsequent repair. It also includes the labor costs to perform scheduled maintenance and inspections on the subsystem.

Off-Equipment Maintenance Cost. This equation gives labor and material costs for base and depot maintenance facilities to diagnose, repair or attempt to repair LRUs. Included are the associated packing and shipping costs incurred for the items expected to be returned to the depot for repairs.

Inventory Entry and Supply Management Cost. This equation gives the management cost to introduce new line items into the Air Force inventory as well as recurring supply management costs.

Support Equipment Cost. This equation computes the cost of peculiar support equipment based on the anticipated workload and servicing capability. The cost of additional units of common support equipment is also included.

Cost of Personnel Training and Training Equipment. This equation gives the initial and recurring costs to train maintenance personnel (instruction and training materials) and the cost of peculiar training equipment required for the subsystem.

Cost of Management and Technical Data. This equation gives the costs for Technical Orders (T.O.s), overhaul manuals, and other special technical documentation or repair instructions. It also computes the maintenance labor costs to complete on- and off- equipment maintenance records, supply transaction records and transportation forms.

Facilities Cost. This equation gives the cost of special base and depot facilities (including utilities) necessary for operation and maintenance of the subsystem.

Fuel Consumption Cost. For systems with propulsion subsystems, this equation gives the cost of fuel for the operational life of the system.

Cost of Spare Engines. When applicable, this equation gives the cost of whole spare engines required in the base and depot pipeline to support the weapon system.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study and analysis of the operating and support (O & S) costs of an Advanced RPV squadron was performed. This study concentrated on the determination of costs for operations and support while the weapon system was still in its conceptual phase of acquisition. It was assumed that early decisions made by the system program manager, with respect to design parameters for a weapon system, can have a major impact on the costs for operating and supporting that weapon system.

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A cost model was formulated, to be used by the ARPV program manager, that provided operating and support cost visibility. Its purpose was as a tool to provide insight into what cost elements were the high cost drivers, Also, it was intended to be useful in applying different operating and support concepts in order to arrive at the most cost effective squadron concept. For this purpose, a squadron operations and maintenance concept was developed to demonstrate the utility of the model. Finally, several cost variables were examined to show their impact on total O & S costs as they were varied over a range of values.

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